

# Appendix A

## Thermal Conversion Factors

### Using Thermal Conversion Factors

The thermal conversion factors presented in the following tables can be used to estimate the heat content in British thermal units (Btu) of a given amount of energy measured in physical units, such as barrels or cubic feet. For example, 10 barrels of asphalt has a heat content of approximately 66.36 million Btu (10 barrels x 6.636 million Btu per barrel = 66.36 million Btu).

The heat content rates (i.e., thermal conversion factors) provided in this section represent the gross (or upper) energy content of the fuels. Gross heat content rates are applied in all Btu calculations for the *Annual Energy Review* and are commonly used in energy calculations in the United States; net (or lower) heat content rates are typically used in European energy calculations. The difference between the two rates is the amount of energy that is consumed to vaporize water that is created during the combustion process. Generally, the difference ranges from 2 percent to 10 percent, depending on the specific fuel and its hydrogen content. Some fuels, such as unseasoned wood, can be more than 40 percent different in their gross and net heat content rates.

In general, the annual thermal conversion factors presented in Tables A2 through A6 are computed from final annual data or from the best available data and are labeled “preliminary.” Often, the previous year’s factor is used as the preliminary value until data become available to calculate the factor appropriate to the year. The source of each factor is described in the section entitled “Thermal Conversion Factor Source Documentation,” which follows Table A6 in this appendix.

Thermal conversion factors for hydrocarbon mixes are weighted averages of the thermal conversion factors for each hydrocarbon included in the mix. For example, in calculating the thermal conversion factor for a 60-40 butane-propane mixture, the thermal conversion factor for butane is weighted 1.5 times the thermal conversion factor for propane.

More information about British thermal units (the standardized unit of measure for energy) can be found in the Glossary.

**Table A1. Approximate Heat Content of Petroleum Products**  
(Million Btu per Barrel)

Energy Source	Heat Content
Asphalt . . . . .	6.636
Aviation Gasoline . . . . .	5.048
Butane . . . . .	4.326
Butane-Propane Mixture (60 percent-40 percent) . . . . .	4.130
Distillate Fuel Oil . . . . .	5.825
Ethane . . . . .	3.082
Ethane-Propane Mixture (70 percent-30 percent) . . . . .	3.308
Isobutane . . . . .	3.974
Jet Fuel, Kerosene-Type . . . . .	5.670
Jet Fuel, Naphtha-Type . . . . .	5.355
Kerosene . . . . .	5.670
Lubricants . . . . .	6.065
Motor Gasoline	
Conventional <sup>1</sup> . . . . .	5.253
Oxygenated <sup>1</sup> . . . . .	5.150
Reformulated <sup>1</sup> . . . . .	5.150
Fuel Ethanol <sup>2</sup> . . . . .	3.539
Natural Gasoline . . . . .	4.620
Pentanes Plus . . . . .	4.620
Petrochemical Feedstocks	
Naphtha less than 401° F . . . . .	5.248
Other Oils equal to or greater than 401° F . . . . .	5.825
Still Gas . . . . .	6.000
Petroleum Coke . . . . .	6.024
Plant Condensate . . . . .	5.418
Propane . . . . .	3.836
Residual Fuel Oil . . . . .	6.287
Road Oil . . . . .	6.636
Special Naphthas . . . . .	5.248
Still Gas . . . . .	6.000
Unfinished Oils . . . . .	5.825
Unfractionated Stream . . . . .	5.418
Waxes . . . . .	5.537
Miscellaneous . . . . .	5.796

<sup>1</sup>See Table A3 for motor gasoline annual weighted averages beginning in 1994.

<sup>2</sup>Fuel ethanol, which is derived from agricultural feedstocks (primarily corn), is not a petroleum product but is blended into motor gasoline. Its gross heat content (3.539 million Btu per barrel) is used in *Annual Energy Review* calculations; its net heat content (3.192 million Btu per barrel) is used in the Energy Information Administration’s *Renewable Energy Annual* calculations.

Source: See “Thermal Conversion Factor Source Documentation,” which follows Table A6.

**Table A2. Approximate Heat Content of Crude Oil, Crude Oil and Products, and Natural Gas Plant Liquids, 1949-2001**  
(Million Btu per Barrel)

Year	Crude Oil Only			Crude Oil and Products		Natural Gas Plant Liquids Production
	Production	Imports	Exports	Imports	Exports	
1949	5.800	5.952	5.800	6.059	5.692	4.544
1950	5.800	5.943	5.800	6.080	5.766	4.522
1951	5.800	5.938	5.800	6.075	5.762	4.495
1952	5.800	5.938	5.800	6.067	5.774	4.464
1953	5.800	5.924	5.800	6.052	5.742	4.450
1954	5.800	5.931	5.800	6.052	5.745	4.415
1955	5.800	5.924	5.800	6.040	5.768	4.406
1956	5.800	5.916	5.800	6.024	5.754	4.382
1957	5.800	5.918	5.800	6.023	5.780	4.369
1958	5.800	5.916	5.800	5.993	5.779	4.366
1959	5.800	5.916	5.800	6.020	5.829	4.311
1960	5.800	5.911	5.800	6.021	5.834	4.295
1961	5.800	5.900	5.800	5.991	5.832	4.283
1962	5.800	5.890	5.800	6.004	5.841	4.273
1963	5.800	5.894	5.800	6.002	5.840	4.264
1964	5.800	5.882	5.800	5.998	5.844	4.268
1965	5.800	5.872	5.800	5.997	5.743	4.264
1966	5.800	5.863	5.800	5.993	5.729	4.259
1967	5.800	5.838	5.800	5.999	5.777	4.232
1968	5.800	5.836	5.800	5.977	5.763	4.218
1969	5.800	5.825	5.800	5.974	5.714	4.170
1970	5.800	5.822	5.800	5.985	5.810	4.146
1971	5.800	5.824	5.800	5.961	5.775	4.117
1972	5.800	5.809	5.800	5.935	5.741	4.070
1973	5.800	5.817	5.800	5.897	5.752	4.049
1974	5.800	5.827	5.800	5.884	5.774	4.011
1975	5.800	5.821	5.800	5.858	5.748	3.984
1976	5.800	5.808	5.800	5.856	5.745	3.964
1977	5.800	5.810	5.800	5.834	5.797	3.941
1978	5.800	5.802	5.800	5.839	5.808	3.925
1979	5.800	5.810	5.800	5.810	5.832	3.955
1980	5.800	5.812	5.800	5.796	5.820	3.914
1981	5.800	5.818	5.800	5.775	5.821	3.930
1982	5.800	5.826	5.800	5.775	5.820	3.872
1983	5.800	5.825	5.800	5.774	5.800	3.839
1984	5.800	5.823	5.800	5.745	5.850	3.812
1985	5.800	5.832	5.800	5.736	5.814	3.815
1986	5.800	5.903	5.800	5.808	5.832	3.797
1987	5.800	5.901	5.800	5.820	5.858	3.804
1988	5.800	5.900	5.800	5.820	5.840	3.800
1989	5.800	5.906	5.800	5.833	5.857	3.826
1990	5.800	5.934	5.800	5.849	5.833	3.822
1991	5.800	5.948	5.800	5.873	5.823	3.807
1992	5.800	5.953	5.800	5.877	5.777	3.804
1993	5.800	5.954	5.800	5.883	5.779	3.801
1994	5.800	5.950	5.800	5.861	5.779	3.794
1995	5.800	5.938	5.800	5.855	5.746	3.796
1996	5.800	5.947	5.800	5.847	5.736	3.777
1997	5.800	5.954	5.800	5.862	5.734	3.762
1998	5.800	5.953	5.800	5.861	5.720	3.769
1999	5.800	5.942	5.800	5.840	5.699	3.744
2000	5.800	R5.959	5.800	R5.849	5.658	3.733
2001 <sup>P</sup>	5.800	5.976	5.800	5.866	5.737	3.735

R=Revised. P=Preliminary.  
Note: Crude oil includes lease condensate.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A3. Approximate Heat Content of Petroleum Product Weighted Averages, 1949-2001**  
(Million Btu per Barrel)

Year	Consumption						Imports	Exports	Liquefied Petroleum Gases Consumption	Motor Gasoline Consumption
	End-Use Sectors				Electric Power Sector <sup>1</sup>	Total				
	Residential	Commercial	Industrial	Transportation						
1949	5.493	5.858	5.947	5.465	6.254	5.649	6.261	5.651	4.011	5.253
1950	5.482	5.865	5.940	5.461	6.254	5.649	6.263	5.751	4.011	5.253
1951	5.492	5.856	5.913	5.458	6.254	5.634	6.265	5.753	4.011	R5.253
1952	5.488	5.849	5.905	5.442	6.254	5.621	6.261	5.768	4.011	5.253
1953	5.465	5.845	5.897	5.426	6.254	5.608	6.268	5.732	4.011	5.253
1954	5.475	5.832	5.883	5.412	6.254	5.595	6.252	5.738	4.011	5.253
1955	5.480	5.832	5.866	5.408	6.254	5.591	6.234	5.765	4.011	5.253
1956	5.474	5.828	5.856	5.406	6.254	5.585	6.225	5.744	4.011	5.253
1957	5.462	5.813	5.842	5.405	6.254	5.577	6.219	5.774	4.011	5.253
1958	5.465	5.802	5.832	5.393	6.254	5.567	6.091	5.778	4.011	5.253
1959	5.408	5.803	5.811	5.389	6.254	5.557	6.142	5.830	4.011	5.253
1960	5.430	5.849	5.800	5.388	6.267	5.555	6.161	5.835	4.011	5.253
1961	5.432	5.847	5.795	5.386	6.268	5.552	6.102	5.833	4.011	5.253
1962	5.418	5.835	5.784	5.386	6.267	5.545	6.138	5.842	4.011	5.253
1963	5.396	5.818	5.759	5.384	6.266	5.534	6.126	5.841	4.011	5.253
1964	5.375	5.811	5.728	5.388	6.267	5.528	6.129	5.845	4.011	5.253
1965	5.380	5.837	5.728	5.387	6.267	5.532	6.123	5.742	4.011	5.253
1966	5.354	5.839	5.722	5.388	6.266	5.532	6.112	5.728	4.011	5.253
1967	5.291	5.818	5.682	5.391	6.266	5.515	6.128	5.758	2.3.838	5.253
1968	5.272	5.797	5.646	5.394	6.263	5.504	6.095	5.762	3.818	5.253
1969	5.213	5.769	5.603	5.394	6.259	5.492	6.093	5.713	3.805	5.253
1970	5.216	5.773	5.604	5.393	6.252	5.503	6.088	5.811	3.779	5.253
1971	5.212	5.758	5.600	5.389	6.245	5.504	6.062	5.775	3.772	5.253
1972	5.193	5.733	5.564	5.388	6.233	5.500	6.045	5.741	3.760	5.253
1973	5.205	5.749	5.568	5.395	6.245	5.515	5.983	5.752	3.746	5.253
1974	5.196	5.740	5.538	5.394	6.238	5.504	5.959	5.773	3.730	5.253
1975	5.192	5.704	5.528	5.392	6.250	5.494	5.935	5.747	3.715	5.253
1976	5.215	5.726	5.538	5.395	6.251	5.504	5.980	5.743	3.711	5.253
1977	5.213	5.733	5.555	5.400	6.249	5.518	5.908	5.796	3.677	5.253
1978	5.213	5.716	5.553	5.404	6.251	5.519	5.955	5.814	3.669	5.253
1979	5.298	5.769	5.418	5.428	6.258	5.494	5.811	5.864	3.680	5.253
1980	5.245	5.803	5.376	5.440	6.254	5.479	5.748	5.841	3.674	5.253
1981	5.191	5.751	5.313	5.432	6.258	5.448	5.659	5.837	3.643	5.253
1982	5.167	5.751	5.263	5.422	6.258	5.415	5.664	5.829	3.615	5.253
1983	5.022	5.642	5.273	5.415	6.255	5.406	5.677	5.800	3.614	5.253
1984	5.129	5.700	5.223	5.422	6.251	5.395	5.613	5.867	3.599	5.253
1985	5.115	5.660	5.221	5.423	6.247	5.387	5.572	5.819	3.603	5.253
1986	5.130	5.691	5.286	5.427	6.257	5.418	5.624	5.839	3.640	5.253
1987	5.095	5.659	5.253	5.430	6.249	5.403	5.599	5.860	3.659	5.253
1988	5.118	5.657	5.248	5.434	6.250	5.410	5.618	5.842	3.652	5.253
1989	5.057	R5.619	R5.234	5.440	RP6.240	5.410	5.641	5.869	3.683	5.253
1990	R4.950	R5.617	5.272	R5.444	RP6.244	5.411	5.614	5.838	3.625	5.253
1991	4.912	R5.590	R5.190	5.442	RP6.246	5.384	5.636	5.827	3.614	5.253
1992	R4.942	R5.577	5.188	5.445	RP6.238	5.378	5.623	5.774	3.624	5.253
1993	R4.942	R5.571	R5.195	5.438	RP6.230	5.379	5.620	5.777	3.606	5.253
1994	R4.936	R5.580	R5.165	R5.426	RP6.213	5.361	5.534	5.777	3.635	3.5.230
1995	R4.925	R5.546	R5.133	5.419	RP6.188	5.341	5.483	5.740	3.623	5.215
1996	R4.869	R5.494	R5.129	5.421	RP6.195	5.336	5.468	5.728	3.613	5.216
1997	R4.870	R5.459	R5.133	5.417	RP6.199	5.336	5.469	5.726	3.616	5.213
1998	R4.842	R5.440	R5.149	R5.414	RP6.210	5.349	5.462	5.710	3.614	5.212
1999	R4.749	R5.349	R5.105	R5.415	RP6.205	5.328	5.421	5.684	3.616	5.211
2000	R4.754	R5.388	R5.072	R5.423	RP6.189	5.326	R5.432	5.651	R3.607	5.210
2001	P4.824	P5.422	P5.120	P5.421	P6.195	P5.346	P5.460	P5.736	P3.614	P5.210

<sup>1</sup> The electric power sector (electric utilities and independent power producers) comprises electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public—i.e., NAICS 22 plants.

<sup>2</sup> There is a discontinuity in this time series between 1966 and 1967; beginning in 1967, the single constant factor is replaced by a quantity-weighted average of liquefied petroleum gases' major components.

<sup>3</sup> There is a discontinuity in this time series between 1993 and 1994; beginning in 1994, the single

constant factor is replaced by a factor that is a quantity-weighted average of motor gasoline's major components. See Table A1.

R=Revised. P=Preliminary.

Note: Weighted averages of the products included in each category are calculated by using heat content values shown in Table A1.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A4. Approximate Heat Content of Natural Gas, 1949-2001**  
(Btu per Cubic Foot)

Year	Production		Consumption			Imports	Exports
	Dry	Marketed	End-Use Sectors	Electric Power Sector <sup>1</sup>	Total		
1949	1,035	1,120	1,035	1,035	1,035	—	1,035
1950	1,035	1,119	1,035	1,035	1,035	—	1,035
1951	1,035	1,114	1,035	1,035	1,035	—	1,035
1952	1,035	1,115	1,035	1,035	1,035	1,035	1,035
1953	1,035	1,116	1,035	1,035	1,035	1,035	1,035
1954	1,035	1,115	1,035	1,035	1,035	1,035	1,035
1955	1,035	1,120	1,035	1,035	1,035	1,035	1,035
1956	1,035	1,116	1,035	1,035	1,035	1,035	1,035
1957	1,035	1,113	1,035	1,035	1,035	1,035	1,035
1958	1,035	1,110	1,035	1,035	1,035	1,035	1,035
1959	1,035	1,109	1,035	1,035	1,035	1,035	1,035
1960	1,035	1,107	1,035	1,035	1,035	1,035	1,035
1961	1,035	1,108	1,035	1,035	1,035	1,035	1,035
1962	1,035	1,107	1,035	1,035	1,035	1,035	1,035
1963	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1964	1,032	1,102	1,032	1,032	1,032	1,032	1,032
1965	1,032	1,101	1,032	1,032	1,032	1,032	1,032
1966	1,033	1,103	1,033	1,033	1,033	1,033	1,033
1967	1,032	1,105	1,032	1,032	1,032	1,032	1,032
1968	1,031	1,115	1,031	1,031	1,031	1,031	1,031
1969	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1970	1,031	1,102	1,031	1,031	1,031	1,031	1,031
1971	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1972	1,027	1,100	1,027	1,027	1,027	1,027	1,027
1973	1,021	1,093	1,020	1,024	1,021	1,026	1,023
1974	1,024	1,097	1,024	1,022	1,024	1,027	1,016
1975	1,021	1,095	1,020	1,026	1,021	1,026	1,014
1976	1,020	1,093	1,019	1,023	1,020	1,025	1,013
1977	1,021	1,093	1,019	1,029	1,021	1,026	1,013
1978	1,019	1,088	1,016	1,034	1,019	1,030	1,013
1979	1,021	1,092	1,018	1,035	1,021	1,037	1,013
1980	1,026	1,098	1,024	1,035	1,026	1,022	1,013
1981	1,027	1,103	1,025	1,035	1,027	1,014	1,011
1982	1,028	1,107	1,026	1,036	1,028	1,018	1,011
1983	1,031	1,115	1,031	1,030	1,031	1,024	1,010
1984	1,031	1,109	1,030	1,035	1,031	1,005	1,010
1985	1,032	1,112	1,031	1,038	1,032	1,002	1,011
1986	1,030	1,110	1,029	1,034	1,030	997	1,008
1987	1,031	1,112	1,031	1,032	1,031	999	1,011
1988	1,029	1,109	1,029	1,028	1,029	1,002	1,018
1989	1,031	1,107	1,031	RP1,028	1,031	1,004	1,019
1990	1,031	1,106	1,030	RP1,027	R1,029	1,012	1,018
1991	1,030	1,108	1,031	RP1,025	1,030	1,014	1,022
1992	1,030	1,110	1,031	RP1,025	1,030	1,011	1,018
1993	1,027	1,106	1,028	RP1,025	1,027	1,020	1,016
1994	1,028	1,105	1,029	RP1,025	1,028	1,022	1,011
1995	1,027	1,106	1,027	RP1,021	R1,026	1,021	1,011
1996	1,027	1,109	1,027	RP1,020	R1,026	1,022	1,011
1997	1,026	1,107	1,027	RP1,020	1,026	1,023	1,011
1998	1,031	R1,109	1,033	RP1,024	1,031	1,023	1,011
1999	1,027	R1,107	1,028	RP1,022	1,027	1,022	1,006
2000	R1,025	R1,107	R1,026	R1,021	R1,025	R1,023	1,006
2001	P1,025	P1,107	P1,026	P1,026	P1,026	P1,023	P1,006

<sup>1</sup> The electric power sector (electric utilities and independent power producers) comprises electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public—i.e., NAICS 22 plants.

R=Revised. P=Preliminary. — = Not applicable.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A5. Approximate Heat Content of Coal and Coal Coke, 1949-2001**

(Million Btu per Short Ton)

Year	Coal									Coal Coke
	Production	Consumption						Imports	Exports	Imports and Exports
		End-Use Sectors				Electric Power Sector <sup>2</sup>	Total			
		Residential and Commercial	Industrial							
			Coke Plants	Other <sup>1</sup>						
1949	24.916	24.263	26.797	24.612	23.761	24.793	25.000	26.759	24.800	
1950	25.090	24.461	26.798	24.820	23.937	24.989	25.020	26.788	24.800	
1951	25.019	24.281	26.796	24.521	23.701	24.813	25.034	26.848	24.800	
1952	25.096	24.371	26.796	24.724	23.885	24.901	25.040	26.859	24.800	
1953	25.147	24.383	26.796	24.785	23.964	25.006	25.048	26.881	24.800	
1954	25.054	24.362	26.795	24.788	23.996	24.913	25.012	26.865	24.800	
1955	25.201	24.373	26.794	24.821	24.056	24.982	25.000	26.907	24.800	
1956	25.117	24.195	26.792	24.664	23.943	24.843	25.000	26.886	24.800	
1957	25.213	24.238	26.792	24.707	23.980	24.905	25.001	26.914	24.800	
1958	24.983	24.287	26.794	24.606	23.897	24.716	25.005	26.931	24.800	
1959	24.910	24.224	26.790	24.609	23.924	24.719	25.003	26.927	24.800	
1960	24.906	24.226	26.791	24.609	23.927	24.713	25.003	26.939	24.800	
1961	24.849	24.248	26.792	24.580	23.904	24.653	25.002	26.937	24.800	
1962	24.828	24.173	26.788	24.562	23.911	24.627	25.013	26.928	24.800	
1963	24.831	24.033	26.784	24.509	23.897	24.588	25.007	26.894	24.800	
1964	24.840	24.037	26.785	24.477	23.864	24.602	25.000	26.949	24.800	
1965	24.775	24.028	26.787	24.385	23.780	24.537	25.000	26.973	24.800	
1966	24.629	23.915	26.786	24.226	23.648	24.396	25.000	26.976	24.800	
1967	24.475	23.685	26.781	24.040	23.506	24.243	25.000	26.981	24.800	
1968	24.445	23.621	26.780	24.014	23.486	24.186	25.000	26.984	24.800	
1969	24.280	23.474	26.779	23.724	23.240	23.976	25.000	26.982	24.800	
1970	23.842	23.203	26.784	22.983	22.573	23.440	25.000	26.982	24.800	
1971	23.507	23.090	26.784	22.670	22.301	23.124	25.000	26.981	24.800	
1972	23.389	22.998	26.782	22.550	22.204	23.036	25.000	26.979	24.800	
1973	23.376	22.831	26.780	22.586	22.246	23.057	25.000	26.996	24.800	
1974	23.072	22.479	26.778	22.419	21.781	22.677	25.000	26.700	24.800	
1975	22.897	22.261	26.782	22.436	21.642	22.506	25.000	26.562	24.800	
1976	22.855	22.774	26.781	22.530	21.679	22.498	25.000	26.601	24.800	
1977	22.597	22.919	26.787	22.322	21.508	22.265	25.000	26.548	24.800	
1978	22.248	22.466	26.789	22.207	21.275	22.017	25.000	26.478	24.800	
1979	22.454	22.242	26.788	22.452	21.364	22.100	25.000	26.548	24.800	
1980	22.415	22.543	26.790	22.690	21.295	21.947	25.000	26.384	24.800	
1981	22.308	22.474	26.794	22.585	21.085	21.713	25.000	26.160	24.800	
1982	22.239	22.695	26.797	22.712	21.194	21.674	25.000	26.223	24.800	
1983	22.052	22.775	26.798	22.691	21.133	21.576	25.000	26.291	24.800	
1984	22.010	22.844	26.799	22.543	21.101	21.573	25.000	26.402	24.800	
1985	21.870	22.646	26.798	22.020	20.959	21.366	25.000	26.307	24.800	
1986	21.913	22.947	26.798	22.198	21.084	21.462	25.000	26.292	24.800	
1987	21.922	23.404	26.799	22.381	21.136	21.517	25.000	26.291	24.800	
1988	21.823	23.571	26.799	22.360	20.900	21.328	25.000	26.299	24.800	
1989	21.765	23.650	26.800	22.347	RP20.873	R21.286	25.000	26.160	24.800	
1990	21.822	23.137	26.799	22.457	RP20.800	R21.216	25.000	26.202	24.800	
1991	21.681	23.114	26.799	22.460	RP20.730	R21.120	25.000	26.188	24.800	
1992	21.682	23.105	26.799	22.250	RP20.709	R21.068	25.000	26.161	24.800	
1993	21.418	22.994	26.800	22.123	RP20.677	R21.010	25.000	26.335	24.800	
1994	21.394	23.112	26.800	22.068	RP20.589	R20.929	25.000	26.329	24.800	
1995	21.326	23.118	26.800	21.950	RP20.543	R20.880	25.000	26.180	24.800	
1996	21.322	23.011	26.800	22.105	RP20.547	R20.870	25.000	26.174	24.800	
1997	21.296	22.494	26.800	22.172	RP20.518	R20.830	25.000	26.251	24.800	
1998	21.418	21.620	27.426	23.164	RP20.516	R20.881	25.000	26.800	24.800	
1999	21.070	23.880	27.426	22.489	RP20.490	R20.818	25.000	26.081	24.800	
2000	21.072	R25.020	27.426	R22.433	RP20.511	R20.828	25.000	26.117	24.800	
2001	P20.905	P25.000	P27.426	P22.433	P20.366	P20.681	25.000	P26.000	24.800	

<sup>1</sup> Includes transportation.

<sup>2</sup> The electric power sector (electric utilities and independent power producers) comprises electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public—i.e., NAICS 22 plants.

R=Revised. P=Preliminary.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels. See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A6. Approximate Heat Rates for Electricity, 1949-2001**  
(Btu per Kilowatthour)

Year	Electricity Net Generation			Electricity Consumption
	Fossil-Fueled Steam-Electric Plants <sup>1</sup>	Nuclear Steam-Electric Plants	Geothermal Energy Plants <sup>2</sup>	
1949	15,033	—	—	3,412
1950	14,030	—	—	3,412
1951	13,641	—	—	3,412
1952	13,361	—	—	3,412
1953	12,889	—	—	3,412
1954	12,180	—	—	3,412
1955	11,699	—	—	3,412
1956	11,456	—	—	3,412
1957	11,365	11,629	—	3,412
1958	11,085	11,629	—	3,412
1959	10,970	11,629	—	3,412
1960	10,760	11,629	23,200	3,412
1961	10,650	11,629	23,200	3,412
1962	10,558	11,629	23,200	3,412
1963	10,482	11,877	22,182	3,412
1964	10,462	11,912	22,182	3,412
1965	10,453	11,804	22,182	3,412
1966	10,415	11,623	22,182	3,412
1967	10,432	11,555	21,770	3,412
1968	10,398	11,297	21,606	3,412
1969	10,447	11,037	21,606	3,412
1970	10,494	10,977	21,606	3,412
1971	10,478	10,837	21,655	3,412
1972	10,379	10,792	21,668	3,412
1973	10,389	10,903	21,674	3,412
1974	10,442	11,161	21,674	3,412
1975	10,406	11,013	21,611	3,412
1976	10,373	11,047	21,611	3,412
1977	10,435	10,769	21,611	3,412
1978	10,361	10,941	21,611	3,412
1979	10,353	10,879	21,545	3,412
1980	10,388	10,908	21,639	3,412
1981	10,453	11,030	21,639	3,412
1982	10,454	11,073	21,629	3,412
1983	10,520	10,905	21,290	3,412
1984	10,440	10,843	21,303	3,412
1985	10,447	R10,622	21,263	3,412
1986	10,446	R10,579	21,263	3,412
1987	10,419	R10,442	21,263	3,412
1988	10,324	R10,602	21,096	3,412
1989	10,432	R10,583	21,096	3,412
1990	10,402	R10,582	21,096	3,412
1991	10,436	R10,484	20,997	3,412
1992	10,342	R10,471	20,914	3,412
1993	10,309	R10,504	20,914	3,412
1994	10,316	R10,452	20,914	3,412
1995	10,312	R10,507	20,914	3,412
1996	10,340	R10,503	20,960	3,412
1997	R10,213	R10,494	20,960	3,412
1998	R10,197	R10,491	21,017	3,412
1999	R10,226	R10,450	21,017	3,412
2000	R10,201	R10,429	21,017	3,412
2001 <sup>P</sup>	10,201	10,442	21,017	3,412

<sup>1</sup> Used as the thermal conversion factor for hydroelectric, solar, and wind electricity net generation.

<sup>2</sup> Used as the thermal conversion factor for geothermal electricity net generation.

R=Revised data. P=Preliminary data. — = Not applicable.

Source: See "Thermal Conversion Factor Source Documentation," which follows this table.

# Thermal Conversion Factor Source Documentation

## Approximate Heat Content of Petroleum and Natural Gas Plant Liquids

**Asphalt.** The Energy Information Administration (EIA) adopted the thermal conversion factor of 6.636 million British thermal units (Btu) per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Aviation Gasoline.** EIA adopted the thermal conversion factor of 5.048 million Btu per barrel as adopted by the Bureau of Mines from the Texas Eastern Transmission Corporation publication *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.

**Butane.** EIA adopted the Bureau of Mines thermal conversion factor of 4.326 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Butane-Propane Mixture.** EIA adopted the Bureau of Mines calculation of 4.130 million Btu per barrel based on an assumed mixture of 60 percent butane and 40 percent propane. See **Butane** and **Propane**.

**Crude Oil, Exports.** Assumed by EIA to be 5.800 million Btu per barrel or equal to the thermal conversion factor for crude oil produced in the United States. See **Crude Oil** and **Lease Condensate, Production**.

**Crude Oil, Imports.** Calculated annually by EIA by weighting the thermal conversion factor of each type of crude oil imported by the quantity imported. Thermal conversion factors for each type were calculated on a foreign country basis, by determining the average American Petroleum Institute (API) gravity of crude imported from each foreign country from Form ERA-60 in 1977 and converting average API gravity to average Btu content by using National Bureau of Standards, Miscellaneous Publication No. 97, *Thermal Properties of Petroleum Products*, 1933.

**Crude Oil and Lease Condensate, Production.** EIA adopted the thermal conversion factor of 5.800 million Btu per barrel as reported in a Bureau of

Mines internal memorandum, "Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950."

**Crude Oil and Petroleum Products, Exports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product exported and crude oil exported weighted by the quantity of each petroleum product and crude oil exported. See **Crude Oil, Exports** and **Exports Petroleum Products**.

**Crude Oil and Petroleum Products, Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product and each crude oil imported weighted by the quantity of each petroleum product and each type of crude oil imported. See **Crude Oil, Imports** and **Petroleum Products, Imports**.

**Distillate Fuel Oil.** EIA adopted the Bureau of Mines thermal conversion factor of 5.825 million Btu per barrel as reported in a Bureau of Mines internal memorandum, "Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950."

**Ethane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.082 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Ethane-Propane Mixture.** EIA calculation of 3.308 million Btu per barrel based on an assumed mixture of 70 percent ethane and 30 percent propane. See **Ethane** and **Propane**.

**Isobutane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.974 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Jet Fuel, Kerosene Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel for "Jet Fuel, Commercial" as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.



**Jet Fuel, Naphtha Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.355 million Btu per barrel for “Jet Fuel, Military” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.

**Kerosene.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Liquefied Petroleum Gases (LPG) Consumption.** Ethane, ethylene, propane, propylene, normal butane, butylene, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate new natural gas plants liquids.

**Lubricants.** EIA adopted the thermal conversion factor of 6.065 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Miscellaneous Products.** EIA adopted the thermal conversion factor of 5.796 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Motor Gasoline.** EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics. Conversion factors for reformulated and oxygenated motor gasolines are calculated by EIA based on data published in the Environmental Protection Agency, Office of Mobile Sources, National Vehicle and Fuel Emissions Laboratory report EPA 420-F-95-003 *Fuel Economy Impact Analysis of Reformulated Gasoline*. Both of the factors are currently 5.150 million Btu per barrel.

**Natural Gas Plant Liquids, Production.** Calculated annually by EIA as the average of the thermal conversion factors of each natural gas plant liquid produced, weighted by the quantity of each natural gas plant liquid produced.

**Natural Gasoline.** EIA adopted the thermal conversion factor of 4.620 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Pentanes Plus.** EIA assumed the thermal conversion factor to be 4.620 million Btu or equal to that for natural gasoline. See **Natural Gasoline**.

**Petrochemical Feedstocks, Naphtha less than 401° F.** Assumed by EIA to be 5.248 million Btu per barrel, equal to the thermal conversion factor for special naphthas. See **Special Naphthas**.

**Petrochemical Feedstocks, Other Oils equal to or greater than 401° F.** Assumed by EIA to be 5.825 million Btu per barrel, equal to the thermal conversion factor for distillate fuel oil. See **Distillate Fuel Oil**.

**Petrochemical Feedstocks, Still Gas.** Assumed by EIA to be 6.000 million Btu per barrel, equal to the thermal conversion factor for still gas. See **Still Gas**.

**Petroleum Coke.** EIA adopted the thermal conversion factor of 6.024 million Btu per barrel as reported in Btu per short ton in the Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.” The Bureau of Mines calculated this factor by dividing 30.120 million Btu per short ton, as given in the referenced Bureau of Mines internal memorandum, by 5.0 barrels per short ton, as given in the Bureau of Mines Form 6-1300-M and successor EIA forms.

**Petroleum Products, Total Consumption.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed, weighted by the quantity of each petroleum product consumed.

**Petroleum Products, Consumption by Electric Utilities.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed at electric utilities, weighted by the quantity of each petroleum product consumed at electric utilities. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA’s *State Energy Data Report*.

**Petroleum Products, Consumption by Industrial Users.** Calculated annually by EIA as the average of the thermal conversion factors for all



petroleum products consumed in the industrial sector, weighted by the estimated quantity of each petroleum product consumed in the industrial sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Consumption by Residential and Commercial Users.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the residential and commercial sector, weighted by the estimated quantity of each petroleum product consumed in the residential and commercial sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Consumption by Transportation Users.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed in the transportation sector, weighted by the estimated quantity of each petroleum product consumed in the transportation sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Exports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product, weighted by the quantity of each petroleum product exported.

**Petroleum Products, Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product imported, weighted by the quantity of each petroleum product imported.

**Plant Condensate.** Estimated to be 5.418 million Btu per barrel by EIA from data provided by McClanahan Consultants, Inc., Houston, Texas.

**Propane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.836 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Residual Fuel Oil.** EIA adopted the thermal conversion factor of 6.287 million Btu per barrel as reported in the Bureau of Mines internal memorandum, "Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950."

**Road Oil.** EIA adopted the Bureau of Mines thermal conversion factor of 6.636 million Btu per barrel, which was assumed to be equal to that of asphalt (see **Asphalt**) and was first published by the Bureau of Mines in the *Petroleum Statement, Annual, 1970*.

**Special Naphthas.** EIA adopted the Bureau of Mines thermal conversion factor of 5.248 million Btu per barrel, which was assumed to be equal to that of the total gasoline (aviation and motor) factor and was first published in the *Petroleum Statement, Annual, 1970*.

**Still Gas.** EIA adopted the Bureau of Mines estimated thermal conversion factor of 6.000 million Btu per barrel, first published in the *Petroleum Statement, Annual, 1970*.

**Unfinished Oils.** EIA assumed the thermal conversion factor to be 5.825 million Btu per barrel or equal to that for distillate fuel (see **Distillate Fuel Oil**) and first published it in EIA's *Annual Report to Congress, Volume 3, 1977*.

**Unfractionated Stream.** EIA assumed the thermal conversion factor to be 5.418 million Btu per barrel or equal to that for plant condensate (see **Plant Condensate**) and first published it in EIA's *Annual Report to Congress, Volume 2, 1981*.

**Waxes.** EIA adopted the thermal conversion factor of 5.537 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

## Approximate Heat Content of Natural Gas

**Natural Gas, Total Consumption.** • 1949-1962: EIA adopted the thermal conversion factor of 1,035 Btu per cubic foot as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*. • 1963-1979: EIA adopted the thermal conversion factor calculated annually by the American Gas Association (AGA) and published in *Gas Facts*, an AGA annual publication. • 1980 forward: Calculated annually by EIA by dividing the total heat content of natural gas consumed by the total quantity of natural gas consumed.

**Natural Gas, Consumption by Electric Utilities.** Calculated annually by EIA by dividing the total heat content of natural gas received at electric

utilities by the total quantity received at electric utilities. The heat contents and receipts are from Form FERC-423 and predecessor forms.

**Natural Gas, Consumption by Sectors Other Than Electric Utilities.**

Calculated annually by EIA by dividing the heat content of all natural gas consumed less the heat content of natural gas consumed at electric utilities by the quantity of all natural gas consumed less the quantity of natural gas consumed at electric utilities. Data are from Forms EIA-176, FERC-423, EIA-759, and predecessor forms.

**Natural Gas, Exports.** • 1949-1972: Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. (See **Natural Gas, Total Consumption**). • 1973 forward: Calculated annually by EIA by dividing the heat content of exported natural gas by the quantity of natural gas exported, both reported on Form FPC-14.

**Natural Gas Imports.** • 1949-1972: Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. See **Natural Gas, Total Consumption**. • 1973 forward: Calculated annually by EIA by dividing the heat content of imported natural gas by the quantity of natural gas imported, both reported on Form FPC-14.

**Natural Gas, Production (Dry).** Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. See **Natural Gas, Total Consumption**.

**Natural Gas, Production, Marketed (Wet).** Calculated annually by EIA by adding the heat content of natural gas, dry production, and the total heat content of natural gas plant liquids production and dividing this sum by the total quantity of marketed (wet) natural gas production.

## Approximate Heat Content of Coal and Coal Coke

**Coal, Total Consumption.** Calculated annually by EIA by dividing the sum of the heat content of coal consumption by the total tonnage.

**Coal, Consumption by Electric Utilities.** Calculated annually by EIA by dividing the sum of the heat content of coal received at electric utilities by the sum of the total tonnage received.

**Coal, Consumption by Other Power Producers.** Calculated annually by dividing the total heat content of coal consumed by other power producers by their total consumption tonnage.

**Coal, Consumption by the Electric Power Sector.** Calculated annually by dividing the total heat content of coal by total consumption tonnage of the electric power sector.

**Coal, Consumption by End-Use Sectors.** Calculated annually by EIA by dividing the sum of the heat content of coal consumed by the end-use sectors by the sum of the total tonnage.

**Coal, Exports.** Calculated annually by EIA by dividing the sum of the heat content of coal exported by the sum of the total tonnage.

**Coal, Imports.** Calculated annually by EIA by dividing the sum of the heat content of coal imported by the sum of the total tonnage.

**Coal, Production.** Calculated annually by EIA by dividing the sum of the total heat content of coal produced by the sum of the total tonnage.

**Coal Coke, Imports and Exports.** EIA adopted the Bureau of Mines estimate of 24,800 million Btu per short ton.

## Approximate Heat Rates for Electricity

**Fossil-Fueled Steam-Electric Plant Generation.** There is no generally accepted practice for measuring the thermal conversion rates for power plants that generate electricity from hydroelectric, wood and waste, wind, photovoltaic, or solar thermal energy sources. Therefore, EIA used data from Form EIA-767, "Steam-Electric Plant Operation and Design Report," to calculate a rate factor that is equal to the prevailing annual average heat rate factor for fossil-fueled steam-electric power plants in the United States. By using that factor, it is possible to evaluate fossil fuel requirements for replacing those sources during periods of interruption, such as droughts. The heat content of a kilowatthour of electricity produced, regardless of the generation process, is 3,412 Btu. • 1949-1955: The weighted annual average heat rate for fossil-fueled steam-electric power plants in the United States, as published by EIA in *Thermal-Electric Plant Construction Cost and Annual Production Expenses-1981* and *Steam-Electric Plant Construction Cost and Annual Production Expenses-1978*. • 1956-1988: The weighted annual average heat

rate for fossil-fueled steam-electric power plants in the United States, as published in EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9. • 1989 forward: Calculated annually by EIA by using the heat rate reported on Form EIA-860, “Annual Electric Generator Report” (and predecessor forms EIA-860A, EIA-860B, and EIA-867), and the generation on Form EIA-906, “Power Plant Report” (and predecessor forms).”

**Geothermal Energy Plant Generation.** • 1960-1981: Calculated annually by EIA by weighting the annual average heat rates of operating geothermal units by the installed nameplate capacities as reported on Form FPC-12, “Power System Statement.” • 1982 forward: Estimated annually by EIA on the basis of an informal survey of relevant plants.

**Nuclear Steam-Electric Plant Generation.** • 1957-1984: Calculated annually by dividing the total heat content consumed in nuclear generating units by the total (net) electricity generated by nuclear generating units. The heat content and electricity generation were reported on Form FERC-1, “Annual Report of Major Electric Utilities, Licensees, and Others”; Form EIA-412, “Annual Report of Public Electric Utilities”; and predecessor forms. The factors for 1982 through 1984 were published in the following EIA reports-1982: *Historical Plant Cost and Annual Production Expenses for Selected Electric Plants 1982*, page 215. 1983 and 1984: *Electric Plant Cost and Power Production Expenses 1991*, Table 13. 1985 forward: Calculated annually by EIA by using the heat rate reported on Form EIA-860, “Annual Electric Generator Report,” and the generation reported on Form EIA-906, “Power Plant Report” (and predecessor forms).



## Appendix B

### Metric and Other Physical Conversion Factors

Data presented in the *Annual Energy Review* and in other Energy Information Administration publications are expressed predominately in units that historically have been used in the United States, such as British thermal units, barrels, cubic feet, and short tons. However, because U.S. commerce involves other nations, most of which use metric units of measure, the U.S. Government is committed to the transition to the metric system, as stated in the Metric Conversion Act of 1975 (Public Law 94-168), amended by the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418), and Executive Order 12770 of July 25, 1991.

The metric conversion factors presented in Table B1 can be used to calculate the metric-unit equivalents of values expressed in U.S. customary units. For

example, 500 short tons is the equivalent of 453.6 metric tons (500 short tons  $\times$  0.9071847 metric tons/short ton = 453.6 metric tons).

In the metric system of weights and measures, the names of multiples and subdivisions of any unit may be derived by combining the name of the unit with prefixes, such as deka, hecto, and kilo, meaning, respectively, 10, 100, 1,000, and deci, centi, and milli, meaning, respectively, one-tenth, one-hundredth, and one-thousandth. Common metric prefixes can be found in Table B2.

The conversion factors presented in Table B3 can be used to calculate equivalents in various physical units commonly used in energy analyses. For example, 10 barrels is the equivalent of 420 U.S. gallons (10 barrels  $\times$  42 gallons/barrel = 420 gallons).

**Table B1. Metric Conversion Factors**

U.S. Unit	<i>multiplied by</i>	Conversion Factor	<i>equals</i>	Metric Unit	U.S. Unit	<i>multiplied by</i>	Conversion Factor	<i>equals</i>	Metric Unit
<b>Mass</b>					<b>Volume</b>				
short tons (2,000 lb)	x	0.907 184 7	=	metric tons (t)	barrels of oil (bbl)	x	0.158 987 3	=	cubic meters (m <sup>3</sup> )
long tons	x	1.016 047	=	metric tons (t)	cubic yards (yd <sup>3</sup> )	x	0.764 555	=	cubic meters (m <sup>3</sup> )
pounds (lb)	x	0.453 592 37 <sup>a</sup>	=	kilograms (kg)	cubic feet (ft <sup>3</sup> )	x	0.028 316 85	=	cubic meters (m <sup>3</sup> )
pounds uranium oxide (lb U <sub>3</sub> O <sub>8</sub> )	x	0.384 647 <sup>b</sup>	=	kilograms uranium (kgU)	U.S. gallons (gal)	x	3.785 412	=	liters (L)
ounces, avoirdupois (avdp oz)	x	28.349 52	=	grams (g)	ounces, fluid (fl oz)	x	29.573 53	=	milliliters (mL)
					cubic inches (in <sup>3</sup> )	x	16.387 06	=	milliliters (mL)
<b>Length</b>					<b>Area</b>				
miles (mi)	x	1.609 344 <sup>a</sup>	=	kilometers (km)	acres	x	0.404 69	=	hectares (ha)
yards (yd)	x	0.914 4 <sup>a</sup>	=	meters (m)	square miles (mi <sup>2</sup> )	x	2.589 988	=	square kilometers (km <sup>2</sup> )
feet (ft)	x	0.304 8 <sup>a</sup>	=	meters (m)	square yards (yd <sup>2</sup> )	x	0.836 127 4	=	square meters (m <sup>2</sup> )
inches (in)	x	2.54 <sup>a</sup>	=	centimeters (cm)	square feet (ft <sup>2</sup> )	x	0.092 903 04 <sup>a</sup>	=	square meters (m <sup>2</sup> )
					square inches (in <sup>2</sup> )	x	6.451 6 <sup>a</sup>	=	square centimeters (cm <sup>2</sup> )
<b>Energy</b>					<b>Temperature</b>				
British Thermal Units (Btu)	x	1,055.055 852 62 <sup>a,c</sup>	=	joules (J)	degrees Fahrenheit (°F)	x	5/9 (after subtracting 32) <sup>a,d</sup>	=	degrees Celsius (°C)
calories (cal)	x	4.186 8 <sup>a</sup>	=	joules (J)					
kilowatthours (kWh)	x	3.6 <sup>a</sup>	=	megajoules (MJ)					

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the Energy Information Administration.

<sup>c</sup>The Btu used in this table is the International Table Btu adopted by the Fifth International Conference on Properties of Steam, London, 1956.

<sup>d</sup>To convert degrees Celsius (°C) to degrees Fahrenheit (°F) exactly, multiply by 9/5, then add 32.

Notes: • Spaces have been inserted after every third digit to the right of the decimal for ease of reading. • Most metric units shown belong to the International System of Units (SI), and the liter, hectare, and

metric ton are accepted for use with the SI units. For more information about the SI units, contact Dr. Barry Taylor at Building 221, Room B610, National Institute of Standards and Technology, Gaithersburg, MD 20899, or on telephone number 301-975-4220.

Sources: General Services Administration, Federal Standard 376B, *Preferred Metric Units for General Use by the Federal Government* (Washington, DC, January 27, 1993), pp. 9-11, 13, and 16. National Institute of Standards and Technology, Special Publications 330, 811, and 814. American National Standards Institute/Institute of Electrical and Electronic Engineers, ANSI/IEEE Std. 268-1992, pp. 28 and 29.



**Table B2. Metric Prefixes**

Unit Multiple	Prefix	Symbol	Unit Multiple	Prefix	Symbol
10 <sup>1</sup>	deka	da	. 10 <sup>-1</sup>	deci	d
10 <sup>2</sup>	hecto	h	. 10 <sup>-2</sup>	centi	c
10 <sup>3</sup>	kilo	k	. 10 <sup>-3</sup>	milli	m
10 <sup>6</sup>	mega	M	. 10 <sup>-6</sup>	micro	
10 <sup>9</sup>	giga	G	. 10 <sup>-9</sup>	nano	n
10 <sup>12</sup>	tera	T	. 10 <sup>-12</sup>	pico	p
10 <sup>15</sup>	peta	P	. 10 <sup>-15</sup>	femto	f
10 <sup>18</sup>	exa	E	. 10 <sup>-18</sup>	atto	a
10 <sup>21</sup>	zetta	Z	. 10 <sup>-21</sup>	zepto	z
10 <sup>24</sup>	yotta	Y	. 10 <sup>-24</sup>	yocto	y

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *The International System of Units (SI)*, NIST Special Publication 330, 1991 Edition (Washington, DC, August 1991), p. 10.

**Table B3. Other Physical Conversion Factors**

Energy Source	Original Unit	multiplied by	Conversion Factor	equals	Final Unit
<b>Petroleum</b>	barrels (bbl)	x	42 <sup>a</sup>	=	U.S. gallons (gal)
<b>Coal</b>	short tons	x	2,000 <sup>a</sup>	=	pounds (lb)
	long tons	x	2,240 <sup>a</sup>	=	pounds (lb)
	metric tons (t)	x	1,000 <sup>a</sup>	=	kilograms (kg)
<b>Wood</b>	cords (cd)	x	1.25 <sup>b</sup>	=	short tons
	cords (cd)	x	128 <sup>a</sup>	=	cubic feet (ft <sup>3</sup> )

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the Energy Information Administration.

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices*, NIST Handbook 44, 1994 Edition (Washington, DC, October 1993), pp. B-10, C-17, and C-21.



# Appendix C

## Carbon Dioxide Emission Factors for Coal

Table C1 presents U.S. average carbon dioxide emission factors for coal by sector. The factors measure the emissions produced during the combustion of coal and were derived from coal sample analyses. The factors are ratios of the carbon dioxide emitted to the heat content of the coal burned,

assuming complete combustion. Factors vary according to the rank and geographic origin of the coal. Sectoral factors reflect the rank and origin of the coal consumed annually in the sector.

**Table C1. Average Carbon Dioxide Emission Factors for Coal by Sector, 1980-2000**  
(Pounds of Carbon Dioxide per Million Btu)

Year	Residential and Commercial	Industrial		Electricity Generation	U.S. Average <sup>b</sup>
		Coke Plants <sup>a</sup>	Other Coal		
1980	210.6	205.8	205.9	206.7	206.5
1981	212.0	205.8	205.9	206.9	206.7
1982	210.4	205.7	206.0	207.0	206.9
1983	209.2	205.5	205.9	207.1	207.0
1984	209.5	205.6	206.2	207.1	207.0
1985	209.3	205.6	206.4	207.3	207.1
1986	209.2	205.4	206.5	207.3	207.1
1987	209.4	205.2	206.4	207.3	207.2
1988	209.1	205.3	206.4	207.6	207.3
1989	209.7	205.3	206.6	207.5	207.3
1990	212.0	206.6	208.7	209.7	209.6
1991	212.6	206.6	209.3	209.9	209.9
1992	213.5	206.5	209.1	210.1	209.9
1993	211.7	206.4	208.3	209.1	209.0
1994	211.1	206.7	208.4	209.2	209.1
1995	211.4	206.7	208.6	209.5	209.4
1996	210.7	206.6	208.2	209.5	209.3
1997	209.6	206.9	208.2	209.4	209.3
1998	210.9	207.1	208.5	209.6	209.5
1999	210.3	206.9	208.6	209.9	209.7
2000	210.5	207.2	208.1	210.0	209.8

<sup>a</sup>No allowances have been made for carbon retained in non-energy coal chemical byproducts from the carbonization process.

<sup>b</sup>Weighted average. The weights used are consumption values by sector.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.



## Appendix D

### U.S. Census Regions and Divisions



Note: Map not to scale.

Source: Adapted from U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 2001* (Washington, DC, November 2001).





# Appendix E

**Table E1. Population and U.S. Gross Domestic Product, 1949-2001**

Year	Population		U.S. Gross Domestic Product		
	United States <sup>1</sup>	World	Billion Nominal Dollars	Billion Chained (1996) Dollars	Implicit Price Deflator <sup>2</sup> (1996 = 1.0000)
	Million People				
1949	148.7	NA	267.7	1,550.9	0.1726
1950	151.3	2,555.1	294.3	1,686.6	0.1745
1951	154.0	2,592.9	339.5	1,815.1	0.1871
1952	156.4	2,634.9	358.6	1,887.3	0.1900
1953	159.0	2,680.3	379.9	1,973.9	0.1925
1954	161.9	2,728.2	381.1	1,960.5	0.1944
1955	165.1	2,779.7	415.2	2,099.5	0.1978
1956	168.1	2,832.6	438.0	2,141.1	0.2045
1957	171.2	2,888.4	461.5	2,183.9	0.2113
1958	174.1	2,944.9	467.9	2,162.8	0.2164
1959	177.1	2,997.3	507.4	2,319.0	0.2188
1960	179.3	3,039.3	527.4	2,376.7	0.2219
1961	183.0	3,080.1	545.7	2,432.0	0.2244
1962	185.7	3,136.2	586.5	2,578.9	0.2274
1963	188.4	3,205.7	618.7	2,690.4	0.2300
1964	191.1	3,276.8	664.4	2,846.5	0.2334
1965	193.5	3,345.8	720.1	3,028.5	0.2378
1966	195.5	3,416.1	789.3	3,227.5	0.2446
1967	197.4	3,485.8	834.1	3,308.3	0.2521
1968	199.3	3,557.7	911.5	3,466.1	0.2630
1969	201.3	3,632.3	985.3	3,571.4	0.2759
1970	203.3	3,707.6	1,039.7	3,578.0	0.2906
1971	206.8	3,785.2	1,128.6	3,697.7	0.3052
1972	209.3	3,862.2	1,240.4	3,898.4	0.3182
1973	211.4	3,938.7	1,385.5	4,123.4	0.3360
1974	213.3	4,014.6	1,501.0	4,099.0	0.3662
1975	215.5	4,088.2	1,635.2	4,084.4	0.4003
1976	217.6	4,160.4	1,823.9	4,311.7	0.4230
1977	219.8	4,232.9	2,031.4	4,511.8	0.4502
1978	222.1	4,305.4	2,295.9	4,760.6	0.4823
1979	224.6	4,380.8	2,566.4	4,912.1	0.5225
1980	226.5	4,456.7	2,795.6	4,900.9	0.5704
1981	229.5	4,533.0	3,131.3	5,021.0	0.6237
1982	231.7	4,613.4	3,259.2	4,919.3	0.6625
1983	233.8	4,693.9	3,534.9	5,132.3	0.6888
1984	235.8	4,773.6	3,932.7	5,505.2	0.7144
1985	237.9	4,854.6	4,213.0	5,717.1	0.7369
1986	240.1	4,937.6	4,452.9	5,912.4	0.7531
1987	242.3	5,023.6	4,742.5	6,113.3	0.7758
1988	244.5	5,110.2	5,108.3	6,368.4	0.8021
1989	246.8	5,196.3	5,489.1	6,591.8	0.8327
1990	R248.8	5,283.8	5,803.2	6,707.9	0.8651
1991	R253.0	5,366.9	5,986.2	6,676.4	0.8966
1992	R256.5	5,449.7	6,318.9	6,880.0	0.9184
1993	R259.9	5,531.0	6,642.3	7,062.6	0.9405
1994	R263.1	5,611.0	7,054.3	7,347.7	0.9601
1995	R266.3	5,690.9	7,400.5	7,543.8	0.9810
1996	R269.4	5,768.6	7,813.2	7,813.2	1.0000
1997	R272.6	5,846.8	8,318.4	8,159.5	1.0195
1998	R275.9	5,924.6	R8,781.5	R8,508.9	R1.0320
1999	R279.0	6,002.5	R9,268.6	R8,856.5	R1.0465
2000	281.4	6,080.1	R9,872.9	R9,224.0	R1.0704
2001	284.8	6,157.4	10,208.1	9,333.8	1.0937

<sup>1</sup> Resident population of the 50 States and the District of Columbia estimated for July 1 of each year, except for the April 1 decennial census counts.

<sup>2</sup> See Glossary.

R=Revised. NA=Not available.

Note: See "Chained Dollars" in the Glossary.

Web Pages: <http://www.census.gov/>. <http://www.bea.doc.gov/>.

Sources: See next page.

## Appendix E

**Sources:** **U.S. Population:** • 1949-1989—Department of Commerce (DOC), U.S. Bureau of the Census, Current Population Reports Series P-25, November 1998. • 1990 forward—DOC, U.S. Bureau of the Census, State Population Estimates. **World Population:** • 1950 forward—DOC, U.S. Bureau of the Census, International Database. **U.S. Gross Domestic Product:** • 1949 forward—DOC, Bureau of Economic Analysis, National Income and Product Accounts.

# Appendix F

**Table F1a. Energy Consumption in the United States, Selected Years, 1635-1945**  
(Quadrillion Btu)

Year	Coal	Natural Gas	Petroleum	Nuclear Electric Power	Hydroelectric Power	Wood
1635	NA	—	—	—	—	(s)
1645	NA	—	—	—	—	0.001
1655	NA	—	—	—	—	0.002
1665	NA	—	—	—	—	0.005
1675	NA	—	—	—	—	0.007
1685	NA	—	—	—	—	0.009
1695	NA	—	—	—	—	0.014
1705	NA	—	—	—	—	0.022
1715	NA	—	—	—	—	0.037
1725	NA	—	—	—	—	0.056
1735	NA	—	—	—	—	0.080
1745	NA	—	—	—	—	0.112
1755	NA	—	—	—	—	0.155
1765	NA	—	—	—	—	0.200
1775	NA	—	—	—	—	0.249
1785	NA	—	—	—	—	0.310
1795	NA	—	—	—	—	0.402
1805	NA	—	—	—	—	0.537
1815	NA	—	—	—	—	0.714
1825	NA	—	—	—	—	0.960
1835	NA	—	—	—	—	1.305
1845	NA	—	—	—	—	1.757
1850	0.219	—	—	—	—	2.138
1855	0.421	—	—	—	—	2.389
1860	0.518	—	0.003	—	—	2.641
1865	0.632	—	0.010	—	—	2.767
1870	1.048	—	0.011	—	—	2.893
1875	1.440	—	0.011	—	—	2.872
1880	2.054	—	0.096	—	—	2.851
1885	2.840	0.082	0.040	—	—	2.683
1890	4.062	0.257	0.156	—	0.022	2.515
1895	4.950	0.147	0.168	—	0.090	2.306
1900	6.841	0.252	0.229	—	0.250	2.015
1905	10.001	0.372	0.610	—	0.386	1.843
1910	12.714	0.540	1.007	—	0.539	1.765
1915	13.294	0.673	1.418	—	0.691	1.688
1920	15.504	0.813	2.676	—	0.775	1.610
1925	14.706	1.191	4.280	—	0.701	1.533
1930	13.639	1.932	5.897	—	0.785	1.455
1935	10.634	1.919	5.675	—	0.831	1.397
1940	12.535	2.665	7.760	—	0.917	1.358
1945	15.972	3.871	10.110	—	1.486	1.261

NA=Not available. — = Not applicable. (s)=Less than 0.0005 quadrillion Btu.

Notes: No data are available for years not shown. See end of section for discussion of geographic coverage of data.

Sources: **Coal, Natural Gas, Petroleum, and Hydroelectric Power:** 1850-1945: *Energy in the American Economy, 1850-1975*, Table VII. **Wood:** 1635-1845: U.S. Department of Agriculture Circular No. 641, *Fuel Wood Used in the United States 1630-1930*, February 1942. This source estimates fuelwood consumption in cords per decade, which were converted to Btu using the conversion factor of 20 million Btu

per cord. The annual average value for each decade was assigned to the fifth year of the decade on the assumption that annual use was likely to increase during any given decade and the average annual value was more likely to reflect mid-decade yearly consumption than use at either the beginning or end of the decade. Values thus begin at 1635 and are plotted at 10-year intervals. 1850-1945: *Energy in the American Economy, 1850-1975*, Table VII. Values are plotted at 5-year intervals. There is a discontinuity in the wood plot between 1945 and 1949 due to changes in definitions. Data through 1945 are for fuelwood only, while thereafter include wood-derived fuel and wood byproducts burned as fuel.

**Table F1b. Energy Consumption in the United States, 1949-2001**  
(Quadrillion Btu)

Year	Coal	Natural Gas <sup>1</sup>	Petroleum <sup>2</sup>	Nuclear Electric Power	Hydroelectric Power <sup>3</sup>	Wood
1949	11.981	5.145	11.883	0	1.449	1.549
1950	12.347	5.968	13.315	0	1.440	1.562
1951	12.553	7.049	14.428	0	1.454	1.535
1952	11.306	7.550	14.956	0	1.496	1.474
1953	11.373	7.907	15.556	0	1.439	1.419
1954	9.715	8.330	15.839	0	1.388	1.394
1955	11.167	8.998	17.255	0	1.407	1.424
1956	11.350	9.614	17.937	0	1.487	1.416
1957	10.821	10.191	17.932	(s)	1.557	1.334
1958	9.533	10.663	18.527	0.002	1.629	1.323
1959	9.518	11.717	19.323	0.002	1.587	1.353
1960	9.838	12.385	19.919	0.006	1.657	1.320
1961	9.623	12.926	20.216	0.020	1.680	1.295
1962	9.906	13.731	21.049	0.026	1.822	1.300
1963	10.413	14.403	21.701	0.038	1.772	1.323
1964	10.964	15.288	22.301	0.040	1.907	1.337
1965	11.581	15.769	23.246	0.043	2.058	1.335
1966	12.143	16.995	24.401	0.064	2.073	1.369
1967	11.914	17.945	25.284	0.088	2.344	1.340
1968	12.331	19.210	26.979	0.142	2.342	1.419
1969	12.382	20.678	28.338	0.154	2.659	1.440
1970	12.265	21.795	29.521	0.239	2.654	1.429
1971	11.598	22.469	30.561	0.413	2.861	1.430
1972	12.077	22.698	32.947	0.584	2.944	1.501
1973	12.971	22.512	34.840	0.910	3.010	1.527
1974	12.663	21.732	33.455	1.272	3.309	1.538
1975	12.663	19.948	32.731	1.900	3.219	1.497
1976	13.584	20.345	35.175	2.111	3.066	1.711
1977	13.922	19.931	37.122	2.702	2.515	1.837
1978	13.766	20.000	37.965	3.024	3.141	2.036
1979	15.040	20.666	37.123	2.776	3.141	2.150
1980	15.423	20.394	34.202	2.739	3.118	2.483
1981	15.908	19.928	31.931	3.008	3.105	2.495
1982	15.322	18.505	30.232	3.131	3.572	2.477
1983	15.894	17.357	30.054	3.203	3.899	2.639
1984	17.071	18.507	31.051	3.553	3.800	2.629
1985	17.478	17.834	30.922	R4.076	3.398	2.576
1986	17.260	16.708	32.196	R4.380	3.446	2.518
1987	18.008	17.744	32.865	R4.754	3.117	2.465
1988	18.846	18.552	34.222	R5.587	2.662	2.552
1989	R19.051	R19.712	34.211	R5.602	R2.987	R2.637
1990	R19.156	R19.718	33.553	R6.104	R3.091	R2.190
1991	R18.992	R20.149	32.845	R6.422	R3.092	R2.190
1992	R19.122	R20.835	33.527	R6.479	2.775	R2.290
1993	R19.835	R21.351	33.841	R6.410	3.077	R2.228
1994	R19.909	R21.842	34.670	R6.694	2.958	R2.315
1995	R20.089	R22.784	34.553	R7.075	R3.452	R2.420
1996	R21.002	R23.196	35.757	R7.087	R3.857	R2.467
1997	R21.445	R23.327	36.266	R6.597	R3.839	R2.349
1998	R21.656	R22.934	36.934	R7.068	R3.472	R2.175
1999	R21.623	R23.008	37.960	R7.610	R3.410	R2.210
2000	R22.580	R24.042	R38.404	R7.862	R3.020	R2.257
2001 <sup>P</sup>	21.928	23.224	38.232	8.028	2.286	2.170

<sup>1</sup> Includes supplemental gaseous fuels.

<sup>2</sup> Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.

<sup>3</sup> Conventional hydroelectric power and hydroelectric pumped storage (pumped storage facility production minus energy used for pumping). Through 1988, includes all electricity net imports. From 1989,

includes only electricity net imports derived from hydroelectric power.

P=Preliminary. R=Revised data. (s)=Less than 0.0005 quadrillion Btu.

Sources: **Wood:** Table 10.1. **All Other Data:** Table 1.3.

## Geographic Coverage Note

Tables F1a and F1b present estimates of U.S. energy consumption by energy source for a period that begins a century and a half before the original 13 colonies formed a political union and continues through the decades during which the United States was still expanding territorially. The question thus arises, what exactly is meant by “U.S. consumption” of an energy source for those years when the United States did not formally exist or consisted of less territory than is now encompassed by the 50 States and the District of Columbia?

The documents used to assemble the estimates, and (as far as possible) the sources of those documents, were reviewed carefully for clues to geographic coverage. For most energy sources, the extent of coverage expanded more rapidly than the Nation, defined as all the official States and the District of Columbia. Estimates or measurements of consumption of each energy source generally appear to follow settlement patterns. That is, they were made for areas of the continent that were settled enough to have economically significant consumption even though those areas were not to become States for years. The wood data series, for example, begins in 1635 and includes 12 of the original colonies (excepting Georgia), as well as Maine, Vermont, and the area that would become the District of Columbia.

By the time the series reaches 1810, the rest of the continental States are all included, though the last of the 48 States to achieve statehood did not do so until 1912. Likewise, the coal data series begins in 1850 but includes consumption in areas, such as Utah and Washington (State), which were significant coal-producing regions but had not yet attained statehood. (Note: No data were available on State-level historical coal consumption. The coal data shown in Table F1a through 1945 describe *apparent* consumption, i.e., production plus imports minus exports. The geographic coverage for coal was therefore based on a tally of coal-producing States listed in various historical issues of *Minerals Yearbook*. It is likely that coal was consumed in States where it was not mined in significant quantities.)

By energy source, the extent of coverage can be summarized as follows:

- **Wood**—All 48 contiguous States and the District of Columbia by 1810; Alaska and Hawaii beginning in 1949.
- **Coal**—35 coal-producing States by 1885.
- **Petroleum and natural gas**—All 48 contiguous States, the District of Columbia, and Alaska by 1885; Hawaii beginning in 1949.
- **Hydroelectric power**—Coverage for 1890 and 1895 is uncertain, but probably the 48 contiguous States and the District of Columbia. Coverage for 1900 through 1945 is the 48 contiguous States, and the District of Columbia; Alaska and Hawaii beginning in 1949.
- **Nuclear electric power**—Coverage is all 50 States and the District of Columbia throughout.





# Appendix G

## Classification of Power Plants into Energy-Use Sectors

The Energy Information Administration (EIA) classifies power plants (both electricity-only and combined-heat-and-power plants) into energy-use sectors based on the North American Industry Classification System (NAICS), which replaced the Standard Industrial Classification (SIC) system in 1997. Plants with a NAICS code of 22 are assigned to the Electric Power Sector; those with NAICS codes beginning with 11, 21, 23, 31, 32, and 33, as well as the codes 2212 and 22131, are assigned to the Industrial Sector; and those with all other codes are assigned to the Commercial Sector. The Form EIA-860B, "Annual Electric Generator Report–Nonutility," asked respondents to indicate the primary purpose of the facility by selecting a NAICS code from the table below. The new Form EIA-860, "Annual Electric Generator Report," asks respondents to indicate the primary purpose of the facility by selecting from the universal list of NAICS codes at: [www.census.gov/epcd/naics02/naicod02.htm](http://www.census.gov/epcd/naics02/naicod02.htm).

### Agriculture, Forestry, and Fishing

- 111 Agriculture production-crops
- 112 Agriculture production, livestock and animal specialties.
- 115 Agricultural services
- 113 Forestry
- 114 Fishing, hunting, and trapping

### Mining

- 2122 Metal mining
- 2121 Coal mining
- 211 Oil and gas extraction
- 2123 Mining and quarrying of nonmetallic minerals except fuels

### Construction

23

### Manufacturing

- 311 Food and kindred products
- 3122 Tobacco products
- 314 Textile and mill products
- 315 Apparel and other finished products made from fabrics and similar materials
- 321 Lumber and wood products, except furniture
- 337 Furniture and fixtures
- 322 Paper and allied products (other than 322122 or 32213)
- 322122 Paper mills, except building paper
- 32213 Paperboard mills
- 323 Printing and publishing
- 325 Chemicals and allied products (other than 325188, 325211, 32512, or 325311)
- 325188 Industrial inorganic chemicals
- 325211 Plastics materials and resins
- 32512 Industrial organic chemicals
- 325311 Nitrogenous fertilizers

- 324 Petroleum refining and related industries (other than 32411)
- 32411 Petroleum refining
- 326 Rubber and miscellaneous plastic products
- 316 Leather and leather products
- 327 Stone, clay, glass, and concrete products (other than 32731)
- 32731 Cement, hydraulic
- 331 Primary metal industries (other than 331111 or 331312)
- 331111 Blast furnaces and steel mills
- 331312 Primary aluminum
- 332 Fabricated metal products, except machinery and transportation equipment
- 333 Industrial and commercial equipment and components except computer equipment
- 335 Electronic and other electrical equipment and components except computer equipment
- 336 Transportation equipment
- 3345 Measuring, analyzing, and controlling instruments, photographic, medical, and optical goods, watches and clocks
- 339 Miscellaneous manufacturing industries

### Transportation and Public Utilities

- 482 Railroad transportation
- 485 Local and suburban transit and interurban highway passenger transport
- 484 Motor freight transportation and warehousing
- 491 United States Postal Service
- 483 Water transportation
- 481 Transportation by air
- 486 Pipelines, except natural gas
- 487 Transportation services

### 513 Communications

### 22 Electric, gas, and sanitary services

- 2212 Natural gas transmission
- 2213 Water supply
- 22132 Sewerage systems
- 562212 Refuse systems
- 22131 Irrigation systems

### Wholesale Trade

- 421 to 422
- Retail Trade
- 441 to 454

### Finance, Insurance, and Real Estate

- 521 to 533

### Services

- 721 Hotels
- 812 Personal services
- 514 Business services
- 8111 Automotive repair, services, and parking
- 811 Miscellaneous repair services
- 512 Motion pictures
- 713 Amusement and recreation services
- 622 Health services
- 541 Legal services
- 611 Education services
- 624 Social services
- 712 Museums, art galleries, and botanical and zoological gardens
- 813 Membership organizations
- 561 Engineering, accounting, research, management, and related services
- 814 Private households
- 514199 Miscellaneous services

### Public Administration

92



# **Appendix H**

## **Estimating and Presenting Power Sector Fuel Use in EIA Publications and Analyses**

This appendix was prepared by an inter-office team under the direction of Mary J. Hutzler. General questions and comments about this document may be referred to Renee Miller (202) 287-1718. Specific technical questions may be referred to:

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## I. Background

The Energy Information Administration (EIA) has comprehensively reviewed and revised how it collects, estimates, and reports fuel use for facilities producing electricity. The review addressed inconsistent reporting of the fuels used for electric power and changes in the electric power marketplace that have been inconsistently represented in various EIA survey forms and publications. For example:

In some cases fuel use by combined-heat-and-power (CHP) plants<sup>1</sup> has been reported as industrial sector fuel use, while in other cases it has been reported as electric power sector fuel use.

Electricity generation and fuel consumption have been categorized and reported in several different ways, such as (1) utility only; (2) utility and independent power producers; or (3) utility, independent power producers, and CHP plants. The restructuring of the power industry is making some of these categories less meaningful.

The goal of EIA's comprehensive review was to improve the quality and consistency of its electric power data throughout all data and analysis products. Because power facilities operate in all sectors of the economy (e.g., in commercial buildings, such as hospitals and college campuses, and industrial facilities, such as paper mills and refineries) and use many fuels, any change to electric power data affects data series in nearly all fuel areas and causes changes in a wide variety of EIA publications.

As a result of the comprehensive review, EIA has made the following changes:

EIA has adjusted all presentations of data on electric power to a consistent format and defined the electric power sector to include electricity-only and CHP plants whose primary business is to sell electricity, or electricity and heat, to the public.

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<sup>1</sup> Combined-heat-and-power plants (CHP) produce both electricity and useful thermal output. EIA formerly referred to these plants as cogenerators, but has determined that CHP better describes the facilities because some of the plants included in EIA's data do not produce heat and power in a sequential fashion, and as a result do not meet the legal definition of cogeneration specified in the Public Utilities Regulatory Policies Act (PURPA).

EIA is providing detail within the electric power sector, commercial sector, and industrial sector on fuel used by CHP plants in those sectors.

EIA has changed the sources of data on fuel used by components of the electric power sector. All tabulations and publications will use data obtained from EIA's surveys of electric power generators. This change in data source contributes to changes in total fuel consumption of natural gas.

EIA has revised its historical data on electric power to resolve data anomalies. The revisions contribute to changes in EIA's electricity series as well as the fuel-use series.

This document provides detail on these changes and describes the reasoning behind the changes and their effects on EIA forms and publications. The *Annual Energy Review (AER) 2001* is the first of the annual publications to be released with the new formats. In the upcoming months, EIA will be releasing other annual publications, followed by the monthly publications. The remainder of this document is organized as follows:

Section II provides an overview of the key changes.

Section III discusses the impacts on multi-fuel publications.<sup>2</sup>

Sections IV through VIII provide specific information for electric power, natural gas, coal, petroleum, and renewable energy surveys and publications, respectively. Although the changes have not yet been implemented in these publications, they are reflected in *AER 2001* for these topics.

Section IX provides information on the estimation of greenhouse gas emissions. These data do not appear in the *AER 2001*, but are based on data in it. Data on greenhouse gas emissions will appear in the upcoming EIA publication, *Emissions of Greenhouse Gases in the United States*.

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<sup>2</sup> Multi-fuel publications are those that provide information on multiple fuels and sectors, such as the *Monthly Energy Review* and the *Annual Energy Review*.

## II. Overview of Key Changes

The many changes that will occur because of the fuel review generally fall into three broad categories: (1) the categorization of electric power facilities, (2) the reporting of combined-heat-and-power plant fuel use, and (3) data series revisions resulting from revised electric power fuel use estimates. Each of these areas is discussed below.

### Categorization of Electric Power Facilities

Until the 1990s, most electric power generation and fuel use data could be meaningfully categorized into electric utilities and nonutility power producers.<sup>3</sup> Electric utilities were generally structured as vertically integrated<sup>4</sup> power companies that were responsible for generating, transmitting, and distributing power to consumers within their franchised service territory. Nonutility power producers were generally independent generators—mostly combined-heat-and-power plants—that produced some power for their own use and sold the remainder to utilities for distribution to consumers. However, in recent years, many formerly integrated utilities have split apart, spinning off the generating part of their business into separate companies. Independent developers have built most of the new generating capacity that has been installed in recent years. As a result, the distinction between utility and nonutility power plants has become much less meaningful. In fact, a large portion of the growth in nonutility generation in recent years is due to the reclassification of utility power plants as nonutility power plants.

To reflect the changing industry structure, EIA is now organizing electric power generation and fuel use data into two new categories: electricity-only and combined-heat-and-power (CHP) plants. These categories separate power plants by function; i.e., power only or power plus thermal, rather than by ownership class.

Electricity-only plants represent all plants, whether owned by utilities or nonutilities that produce only electricity. CHP plants represent entities that

produce both electricity and some form of thermal energy. Both categories will have some facilities that are owned by traditional utilities and independent companies.

In addition, EIA is now presenting data for an electric power sector that includes electricity-only plants and CHP plants whose primary business is to sell electricity, or electricity and heat, to the public (North American Industry Classification System code 22). This contrasts with some previous data presentations in which the electric power sector included industrial and commercial CHP plants as well (Figure H1).

**Figure H1. Electric Power Sector in AER 2001 and AER 2000**

AER 2001			AER 2000		
Electric Power Sector <sup>1,2</sup>			Electric Power Sector <sup>1</sup>		
Electricity Only	CHP	Total	Electric Utilities	Nonutility Power Producers	Total

In some tables and publications, the electric power sector will continue to be broken down into electric utilities and independent power producers for customers who have expressed an interest in this breakout. For example, Table 8.1 of *AER 2001* presents an electricity overview and shows data on net generation for electric utilities and independent power producers separately. It is the only table in *AER 2001* that has this break-out (Figure H2).

**Figure H2. Electric Utilities and Independent Power Producers are shown separately in Electricity Overview**

Year	Net Generation					
	Electric Power Sector <sup>1</sup>			Commercial Sector <sup>2</sup>	Industrial Sector <sup>3</sup>	Total
	Electric Utilities	Independent Power Producers	Total			

<sup>3</sup> For an example of this, see *Electric Power Annual 1998*, Volume II, DOE/EIA-0348(98)/2, December 1999.

<sup>4</sup> In this context "integrated" means that the company is involved in the three main sectors of the electric power business—generation, transmission, and distribution.

<sup>1</sup> The electric power sector (electric utilities and independent power producers) comprises electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public—i.e., NAICS 22 plants. Due to the restructuring of the electric power sector, the sale of generation assets is resulting in a reclassification of plants from electric utilities to independent power producers.

## Reporting of CHP Facility Fuel Use

Historically, fuel consumption in CHP plants has been combined with other uses in many EIA publications. For example, in some tables the use of natural gas in commercial and industrial CHP plants was included with other commercial and industrial uses. Further, some of the fuel consumption (the portion associated with electricity production) at these same facilities was also reported under the column labeled “Nonutility Power Producers.” Based on questions received, it became clear that this categorization led to confusion for many EIA customers.

In the future, EIA will distinguish within the industrial, commercial, and electric power sectors what portion of fuel consumption is used in CHP facilities and non-CHP facilities. For example:

In tabulations of energy use by economic sector, if a commercial or industrial facility has a CHP unit, the total fuel consumption for that unit will be reported under commercial or industrial, but it will be identified separately from other commercial or industrial consumption. Figure H3 provides an example for natural gas consumption in the industrial sector. It shows the headings in Table 6.5 of *AER 2001* compared with the headings for the same table in *AER 2000*.

**Figure H3. Industrial Sector in AER 2001 and AER 2000**

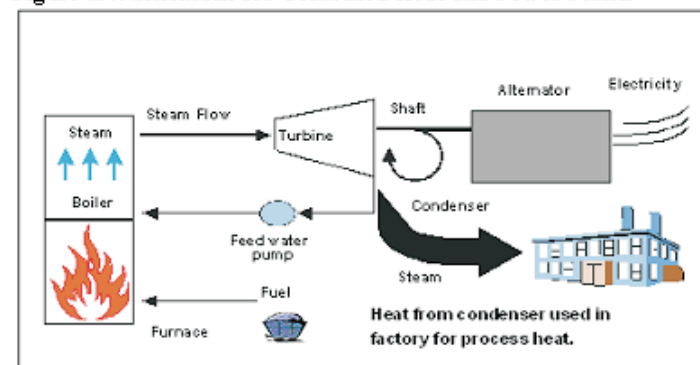
AER 2001				AER 2000		
End-Use Sectors				End-Use Sectors		
Industrial				Industrial <sup>2</sup>		
Other Industrial				Delivered to Industrial Facilities	Lease and Plant Fuel	Total
Lease and Plant Fuel	CHP <sup>1</sup>	Non-CHP <sup>1</sup>	Total			

CHP plants that report their primary business is generating and selling power to others will be reported in a separate column in the electric power sector, as shown in Figure H1.

In tabulations of energy use to produce electric power, the total fuel consumption reported by CHP plants will be further separated into that which is used to produce electricity and that

which is used to produce thermal energy.<sup>5</sup> See Tables 8.3b,c, and d of *AER 2001*. Figure H4 shows a schematic for combined heat and power producers.

**Figure H4. Schematic for Combined Heat and Power Plants**



The separation between electricity and thermal uses is being done because many EIA data users have expressed interest in knowing how much fuel is used to produce electricity in the United States.

## Data Series Revisions Resulting From Changes in Electric Power Fuel Use Estimates

The revisions to electric power data affect many areas. For example, historically, to estimate natural gas use, EIA surveyed natural gas pipeline-companies and local gas utilities to obtain data on natural gas used by residential, commercial, industrial, and electric utility sectors, and nonutility generators.<sup>6</sup> However, EIA also surveyed electric utilities on their natural gas use. These data obtained directly from the end user were generally thought to be more accurate than the data obtained from natural gas suppliers. As a result, total natural gas use was estimated by adding together the data from natural gas companies on residential, commercial, industrial, and nonutility power producer use to the amount reported directly

<sup>5</sup> For the method used to separate the fuel used at CHP plants between electricity and useful thermal energy production, see Section IV.

<sup>6</sup> Energy Information Administration, Form EIA-176, "Annual Report of Natural and Supplemental Gas Supply and Disposition."



by electric utilities. The data collected for nonutility power producers were included with industrial use in previous EIA natural gas publications.

With the changing structure of the electricity sector, this reporting approach no longer appears reasonable. EIA has decided to follow the procedure described for electric utilities and use data obtained from its direct surveys of nonutility electric generators rather than the natural gas supplier surveys.<sup>7</sup> More detail on how the various fuel sectors are affected is given in the following sections.

Data changes are also occurring because of the extensive review of reported data that was undertaken in this process. Since it was decided that data reported directly by utilities and nonutility power generators would be the primary source of fuel consumption data for the power sector, an examination of heat rates,<sup>8</sup> capacity factors,<sup>9</sup> and power-to-steam ratios across 12 years of reported data was conducted. As a result, data for nonutility power producers for 1989 through 2000 have been revised. The data review procedure is described in Section IV under the heading "Efforts to Improve Data." As a result of the review by expert EIA analysts, anomalous values have been investigated and resolved and the result is higher quality data at aggregated levels.

Revisions resulting from changing the source of fuel consumption data for nonutilities and from EIA's data review affect data beyond the category of nonutilities. For example, the revised estimate of natural gas consumption for 2000 is 3 percent higher (.75 trillion cubic feet) in the *Annual Energy Review (AER) 2001* than in *AER 2000* (Table H1 and Figure H5).

On the other hand, the revised estimate of renewable energy consumption for 2000 is 5 percent lower in *AER 2001* than in *AER 2000* (Figure H6), due largely to a downward revision in the estimate of biomass energy consumption particularly wood/wood waste at electric power plants. A

<sup>7</sup> Energy Information Administration, Form EIA-759, "Monthly Power Plant Report" for electric utilities and Forms EIA-867 and EIA-860B, "Annual Electric Generator Report-Nonutility" for nonutilities. Starting with 2001, data for both utilities and nonutilities are collected on a new survey, Form EIA-906, "Power Plant Report."

<sup>8</sup> Heat rates are computed by dividing the heat content of the fuel burned to generate electricity by the resulting net kilowatt-hour generation.

<sup>9</sup> Capacity factors are the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

**Table H1. Revisions to Selected Estimates: AER 2001 and AER 2000**

**Electricity Net Generation: Total (All Sectors)**

(Billion Kilowatthours)

Year	AER 2000	AER 2001	Percent Difference
1998	3,618	3,620	0.1
1999	3,706	3,695	-0.3
2000	3,792	3,802	0.3

**Total Natural Gas Consumption**

(Trillion Cubic feet)

Year	AER 2000	AER 2001	Percent Difference
1998	21.26	22.24	4.6
1999	21.70	22.40	3.2
2000	22.71	23.46	3.3

**Total Coal Consumption**

(Million Short Tons)

Year	AER 2000	AER 2001	Percent Difference
1998	1,038.30	1,037.10	-0.1
1999	1,045.30	1,038.60	-0.6
2000	1,079.70	1,084.10	0.4

**Total Petroleum Consumption**

(Million Barrels Per Day)

Year	AER 2000	AER 2001	Percent Difference
1998	18.92	18.92	0.0
1999	19.52	19.52	0.0
2000	19.48	19.70	1.1

**Total Renewable Energy Consumption**

(Trillion Btu)

Year	AER 2000	AER 2001	Percent Difference
1998	6,977	6,782	-2.8
1999	7,226	6,790	-6.0
2000	6,823	6,465	-5.2

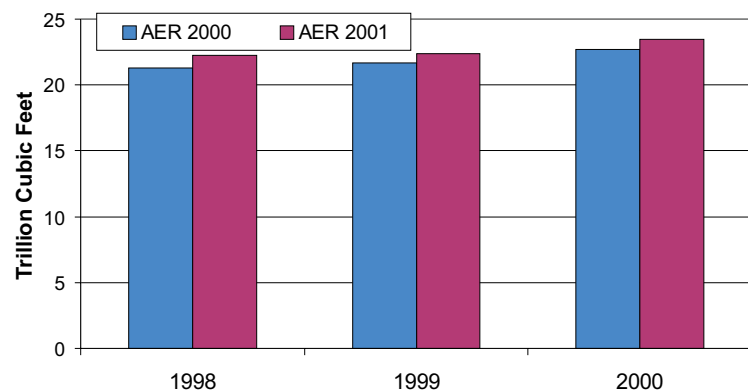
**Sources:** Electricity Net Generation, Table 8.1 of *AER 2000* and *AER 2001*. Natural Gas, Consumption, Table 6.5 of *AER 2000* and *AER 2001*. Coal Consumption, Table 6.5 of *AER 2000* and *AER 2001*. Petroleum Consumption, Table 5.12 of *AER 2000* and *AER 2001*. Renewable Energy Consumption, Table 10.2b of *AER 2000* and *AER 2001*.

smaller revision resulted from the procedure to assign fuel consumption by energy type at some solar and hydroelectric plants. In *AER 2001*, the assignment was made at the boiler level while in *AER 2000* it was based on aggregate plant-level information.

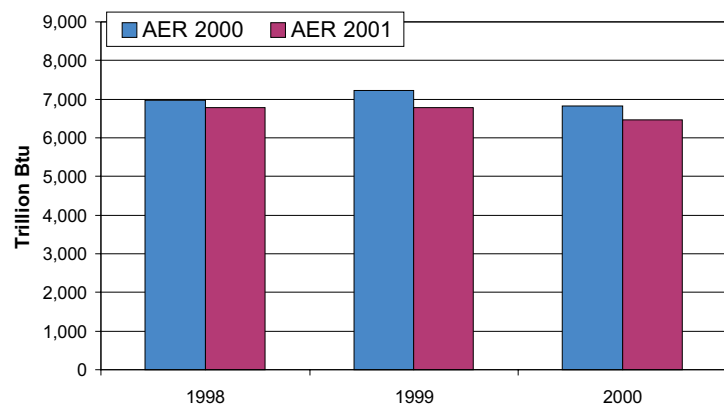
Estimates for petroleum and coal consumption show little change between the 2000 and 2001 *AERs* for the same year. This is also true for electricity net generation.

In addition, as a result of the recategorization of nonutility data, estimates of industrial natural gas consumption have been revised and are lower. For example, in *AER 2000* EIA showed 9.39 trillion cubic feet delivered to industrial facilities in 2000. In *AER 2001* the comparable figure (under the

**Figure H5. Impact of Revisions to Total Natural Gas Consumption**



**Figure H6. Impact of Revisions to Total Renewable Energy Consumption**



“other industrial” heading) for 2000 is 8.25 trillion cubic feet (Figure H7). This change is a result of the change in the operational definition of deliveries to the industrial sector, which is explained in Section V.

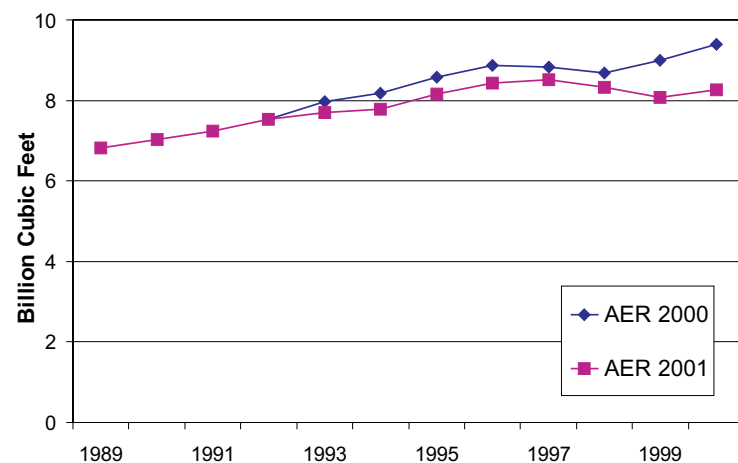
Because the natural gas consumption table in the AER best illustrates the changes that have been made, Table 6.5 of *AER 2001* and *AER 2000* are presented here for comparison.

<http://www.eia.doe.gov/emeu/aer/txt/ptb0605.html>

<http://www.eia.doe.gov/emeu/aer/txt/tab0605.htm>

To summarize the changes, data for combined-heat-and-power plants are shown separately by end-use sector in *AER 2001* while they are included with the sector totals for *AER 2000*. Independent power producers are excluded from the industrial sector in *AER 2001* and included in the electric power sector. Data are based on a survey of electric generators. By contrast, independent power producers were included in the industrial sector in *AER 2000* and data were based on a survey of natural gas suppliers.

**Figure H7. Industrial Natural Gas Consumption: AER 2001 and AER 2000**



Note: AER 2000 Industrial equals “Deliveries to Industrial Facilities.”  
AER 2001 Industrial equals “Other Industrial Total.”



### III. Multi-Fuel Publications

EIA's multi-fuel publications—i.e., those that report data on numerous energy sources and provide overall energy totals—will be reformatted to incorporate the new approach described in detail in the preceding sections. The *Annual Energy Review 2001* is the first of the historical multi-fuel publications to be released with the new formats. In the months ahead, EIA will undertake the redesign of the *Monthly Energy Review* (MER) to make its data and presentations conform to the new AER. In addition to the MER, the State-level consumption, price, and expenditure estimates that have previously been released under the titles *State Energy Data Report* and *State Energy Price and Expenditure Report* will be reformatted beginning with the 2001 update; the 2000 updates are now in final processing and will not conform to the new AER formats. Coordinated data and presentation changes will also be incorporated into EIA's forecast products—the *Short-Term Energy Outlook* (STEO) and the *Annual Energy Outlook* (AEO).

The *Annual Energy Review 2001* (AER 2001) includes many redesigned tables (and related graphs) that were adapted to present the new electricity data. Revised tables fall into three groupings: electricity, fuels, and total energy. These tables are interrelated.

Table 8.3e provides data on fuel consumption for both electricity generation and useful thermal output. Data on consumption by the electric power sector on Table 8.3e correspond with data for this sector on fuel consumption tables (e.g., Table 6.5 on natural gas, Table 7.3 on coal, and Table 10.2b on renewable energy consumption). See Figure H8 for natural gas.

Similarly, data on commercial sector CHP plants on Table 8.3e correspond with the commercial sector CHP columns of the fuel consumption tables and data on industrial sector CHP plants on Table 8.3e correspond with the industrial sector CHP columns of the fuel consumption tables.

Table 8.3a provides data on consumption of combustible fuels for electricity generation. Data on the amount of fossil fuel (such as coal, residual fuel oil, and natural gas) and on the amount of renewable energy used to generate electricity at both electricity-only and combined-heat-and-power (CHP) plants can be found on this table.

Table 8.3a data on fuel consumed for electricity generation differ from those for the electric power sector on the fuel consumption tables (e.g., Table 6.5 for natural gas) because the electric power sector includes entities that produce thermal energy as well as electricity (CHP plants whose primary business is to sell electricity). In addition, there are entities that generate electricity that are not in the electric power sector (commercial sector CHP plants and industrial sector CHP plants). Table 8.3d provides data on consumption for useful thermal output at CHP plants.

**Electricity Tables.** Most AER 2000 electricity tables were altered in format for presentation in the AER 2001. This crosswalk provides the relationship from each AER 2000 table to its closest match in the AER 2001:

AER 2000	AER 2001	Title in the AER 2001
8.1	8.1	Electricity Overview
8.2	8.2a	Electricity Net Generation: Total (All Sectors)
8.3	8.2b	Electricity Net Generation at Electricity-Only Plants: Electric Power Sector
8.4	8.2c	Electricity Net Generation at Combined-Heat-and-Power Plants by Sector
---	8.2d	Useful Thermal Output at Combined-Heat-and-Power-Plants by Sector
8.8	8.3a	Consumption of Combustible Fuels for Electricity Generation: Total (All Sectors)
8.9	8.3b	Consumption of Combustible Fuels for Electricity Generation at Electricity-Only Plants: Electric Power Sector
8.10	8.3c	Estimated Consumption of Combustible Fuels for Electricity Generation at Combined-Heat- and-Power-Plants by Sector
---	8.3d	Estimated Consumption of Combustible Fuels for Useful Thermal Output at Combined-Heat-and-Power Plants by Sector
---	8.3e	Consumption of Combustible Fuels for Electricity Generation and Useful Thermal Output at Electricity-Only and Combined-Heat-and-Power Plants by Sector
8.11	8.4	Stocks of Coal and Petroleum: Electric Power Sector
8.12	8.5	Electricity End Use
8.15	8.6	Average Retail Prices of Electricity
8.5	8.7a	Electric Net Summer Capacity: Total (All Sectors)
8.6	8.7b	Electric Net Summer Capacity at Electricity-Only Power Plants: Electric Power Sector
8.7	8.7c	Electric Net Summer Capacity at Combined-Heat-and-Power Plants by Sector
8.14	8.8	Electric Noncoincident Peak Load and Capacity Margin
8.13	8.9	Electric Utility Demand-Side Management Programs

**Figure H8. Consumption of Natural Gas in Electric Power Sector: AER Table 8.3e and Table 6.5**

Fossil Fuel Portion of Table 8.3e for Electric Power Sector: AER 2001

	Fossil Fuels					
	Coal <sup>1</sup>	Distillate Fuel Oil	Residual Fuel Oil	Other Liquids <sup>2</sup>	Petroleum Coke	Natural Gas <sup>3</sup>
Year	Thousand Short Tons	Thousand Barrels			Thousand Short Tons	Billion Cubic Feet
Electric Power Sector (Electric Utilities and Independent Power Producers)						
1989 <sup>P</sup>	772,190	<sup>9</sup> 26,156	<sup>10</sup> 244,179	10	517	3,105
1990 <sup>P</sup>	780,987	<sup>9</sup> 16,400	<sup>10</sup> 183,375	26	983	3,234
1991 <sup>P</sup>	783,874	<sup>9</sup> 14,359	<sup>10</sup> 172,625	59	974	3,316
1992 <sup>P</sup>	795,094	<sup>9</sup> 12,623	<sup>10</sup> 138,726	128	1,494	3,448
1993 <sup>P</sup>	831,645	<sup>9</sup> 14,849	<sup>10</sup> 152,481	239	2,611	3,473
1994 <sup>P</sup>	838,354	<sup>9</sup> 20,612	<sup>10</sup> 138,222	771	2,315	3,903
1995 <sup>P</sup>	850,230	<sup>9</sup> 18,553	<sup>10</sup> 90,023	499	2,674	4,237
1996 <sup>P</sup>	896,921	<sup>9</sup> 18,780	<sup>10</sup> 99,951	653	2,642	3,807
1997 <sup>P</sup>	921,364	<sup>9</sup> 18,989	<sup>10</sup> 113,669	152	3,372	4,065
1998 <sup>P</sup>	936,619	<sup>9</sup> 23,300	<sup>10</sup> 166,528	431	4,102	4,588
1999 <sup>P</sup>	940,922	<sup>9</sup> 24,058	<sup>10</sup> 152,493	544	3,735	4,820
2000 <sup>P</sup>	985,821	<sup>9</sup> 30,016	<sup>10</sup> 138,513	454	3,275	5,206
2001 <sup>P</sup>	966,739	<sup>9</sup> 30,849	<sup>10</sup> 157,486	397	3,660	5,261

Electric Power Sector Portion of Table 6.5 for AER 2001

**Table 6.5 Natural Gas Consumption by Sector, 1949-2001**  
(Trillion Cubic Feet)

Year	Electric Power Sector <sup>1,2</sup>		
	Electricity Only	CHP	Total
1989	2.11 <sup>P</sup> 2.79	10.11 <sup>P</sup> 0.31	2.11 <sup>P</sup> 3.11
1990	11 <sup>P</sup> 2.79	10.11 <sup>P</sup> 0.44	11 <sup>P</sup> 3.23
1991	11 <sup>P</sup> 2.82	10.11 <sup>P</sup> 0.49	11 <sup>P</sup> 3.32
1992	11 <sup>P</sup> 2.83	10.11 <sup>P</sup> 0.62	11 <sup>P</sup> 3.45
1993	<sup>P</sup> 2.76	10. <sup>P</sup> 0.72	<sup>P</sup> 3.47
1994	<sup>P</sup> 3.06	10. <sup>P</sup> 0.84	<sup>P</sup> 3.90
1995	<sup>P</sup> 3.29	10. <sup>P</sup> 0.95	<sup>P</sup> 4.24
1996	<sup>P</sup> 2.82	10. <sup>P</sup> 0.98	<sup>P</sup> 3.81
1997	<sup>P</sup> 3.04	10. <sup>P</sup> 1.03	<sup>P</sup> 4.06
1998	<sup>P</sup> 3.54	10. <sup>P</sup> 1.04	<sup>P</sup> 4.59
1999	<sup>P</sup> 3.73	10. <sup>P</sup> 1.09	<sup>P</sup> 4.82
2000	<sup>P</sup> 4.09	10. <sup>P</sup> 1.11	<sup>P</sup> 5.21
2001	<sup>P</sup> 4.08	10. <sup>E</sup> 1.18	<sup>P</sup> 5.26

**Fuel Tables.** The following AER 2001 fuel tables were reformatted from the previous year's report to incorporate the new electricity information:

- 5.12a Petroleum Consumption: Residential and Commercial Sectors
- 5.2b Petroleum Consumption: Industrial Sector
- 5.12d Petroleum Consumption: Electric Power Sector
- 5.13 Oil and Kerosene Adjusted Sales
- 6.5 Natural Gas Consumption by Sector
- 7.3 Coal Consumption by Sector
- 7.5 Coal Stocks by Sector
- 10.2a Renewable Energy Consumption: End-Use Sectors
- 10.2b Renewable Energy Consumption: Electric Power Sector, Electricity Trade, and Total
- 12.2 Carbon Dioxide Emissions From Energy Consumption by Sector
- 12.3 Carbon Dioxide Emissions From Energy Consumption by Sector by Energy Source
- 12.7 Emissions From Electricity Generation
- A3 Approximate Heat Content of Petroleum Product Weighted Averages
- A4 Approximate Heat Content of Natural Gas
- A5 Approximate Heat Content of Coal and Coal Coke

**Total Energy Tables.** The following AER 2001 tables summarize all energy consumption and include format changes that are related to the new electricity information:

- 2.1a Energy Consumption by Sector
- 2.1c Commercial Energy Consumption Sector
- 2.1d Industrial Energy Consumption Sector
- 2.1f Electric Power Sector Energy Consumption

AER 2000 Table 2.1f is replaced in the AER 2001 with:

- 2.2a Energy Consumption for Electricity Generation: Total (All Sectors)
- 2.2b Energy Consumption for Electricity Generation: Electric Power Sector
- 2.2c Consumption for Electricity Generation: Commercial and Industrial Sectors

## IV. Electric Power Surveys and Publications

### Summary of Key Changes

EIA previously presented data on electric power, such as generation and fuel consumption, in the following categories:

- Electric utilities,
- Nonutility power producers (independent power producers and combined-heat-and power plants),
- Electric power industry (sum of electric utilities and nonutility power producers).

Now EIA is presenting data for the following new categories:

- Electricity-only-plants
- Combined-heat-and-power (CHP) plants,
- U.S. power producers (sum of electricity-only plants and CHP plants and equal to the prior "electric power industry" category).

Data on electricity-only plants are disaggregated for utilities and independent power producers, as there are customers who are interested in maintaining this distinction. Data on CHP plants are disaggregated by the end-use category (commercial, industrial, electric power) they report as their major line of business. The categorization is based on their North American Industrial Classification System code. For example, a CHP plant that is part of a hospital will be classified as "commercial." Similarly, a CHP plant that reports that it is part of a paper mill will be classified as "industrial," and a plant that reports that its primary business is selling power to others will be classified as "electric power."

In addition, EIA has estimated and is presenting data on the amount of fuel used to generate electricity and the amount of fuel used for useful thermal output. Furthermore, during the course of recategorizing the data, EIA performed a thorough data quality review and revised data to resolve anomalies.

### Efforts to Improve Data

EIA reviewed electric power-data from 1989 through 2001 to determine whether there were anomalies. The 1989–2000 data for nonutilities were from Form EIA-860B, "Annual Electric Generator Report-Nonutility," and its predecessor, Form EIA-867, "Annual Nonutility Power Producer

Report.” The 2001 data are from Form EIA-906, “Power Plant Report.” These forms collect data on fuel consumption, generation, and, with the exception of 1995 through 1997, useful thermal output. When anomalies were identified in the data for the more recent years (1998–2001), EIA contacted selected respondents to resolve the inconsistencies. For the historical data it was not possible to contact respondents. In this situation EIA made data adjustments to resolve the anomalies.

EIA reviewed data for facilities with heat rates greater than 40,000 Btu per kilowatthour and less than 5,500 Btu per kilowatthour. The upper limit was chosen to allow for the heat rates of older non-electricity boilers. In addition, EIA reviewed data for facilities with overall efficiency of greater than 100 percent and identified facilities with thermal output that were not designated as CHP plants. To ensure consistency, EIA compared North American Industry Classification System (NAICS) codes, cogenerator status, fuel consumption, electric generation, and thermal output levels over time. Moreover, EIA analysts also reviewed and evaluated aggregate-level data by State, NAICS code, fuel type, and generator type. For the historical data (1989–1997), EIA also:

- Estimated a value for useful thermal output for 1995 through 1997 (when useful thermal output was not included on the survey form) that produced a heat rate between 5,500 and 40,000 Btu per kilowatthour and an efficiency rate consistent with that observed in other years (see discussion below on CHP fuel use methodology).
- Corrected errors in units reported for fuel consumption.
- Compared data on fuel consumption with data on electric generation and adjusted data on fuel consumption or generation to maintain a consistent ratio.
- Adjusted data on useful thermal output for those respondents with heat rates outside the 5,500-to-40,000 Btu per kilowatthour range and an efficiency rate consistent with other years.

The review included an examination of both respondent-level data and aggregate-level data. For the 1998–2000 data, the review also included a comparison for consistency with data reported by manufacturing plants on Form EIA-3, “Quarterly Coal Consumption—Manufacturing Plants,” since a subset of the EIA-3 manufacturing plants generate electricity and also reported on the electric generator survey Form EIA-860B. In general, there was good correspondence between the data submissions. In situations where there were inconsistencies, selected respondents were contacted to explain the differences. The analysis revealed that in some instances there were legitimate explanations for high percentage differences, such as a

respondent reporting data for a facility on one survey that should not be included in the other survey.

For 2001, EIA determined that the monthly submissions for a substantial number of facilities were not of high enough quality. For those facilities in question and for all of the facilities that submit data only on an annual basis, EIA substituted that facility’s 2000 data submission for total fuel consumption, electricity generation, and useful thermal output to obtain estimates for *AER 2001*. EIA is in the process of reviewing and revising these submissions for release at a later date.

### **Allocating CHP Fuel Use**

Because respondents do not keep records on how much fuel a CHP plant uses exclusively to produce electricity, EIA developed the following method for estimating how the total fuel consumed in the boiler is split between electricity generation and useful thermal output:

First, a steam boiler efficiency rate of 80 percent was assumed.<sup>10</sup>

Then the reported or estimated value for useful thermal output (in Btu) was divided by 0.8 to estimate the fuel used to generate this amount of thermal output.

Next, this value was subtracted from total fuel consumption and the remainder was assumed to be the amount used for electric generation.

### **Electric Power Publication Tables Affected**

In both the *Electric Power Monthly* and the *Electric Power Annual*:

- Data will be shown for the following categories throughout most of the report: (1) U.S. power producers, (2) electricity-only plants, and (3) CHP plants (commercial, industrial, and electric power). Data on fuel consumption are shown for both electric generation and thermal output.
- The lowest level of aggregation is at the State level.
- Data on petroleum coke are converted to barrels and included in petroleum consumption and stocks tables.
- Fuel types are revised to be consistent with the *Annual Energy Review*.

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<sup>10</sup> Arthur D. Little, Report to the Energy Information Administration, Industrial Model: *Update on Energy Use and Industrial Characteristics*, (September 2001), Appendix C, “Average Boiler Efficiencies.”

## V. Natural Gas Surveys and Publications

### Summary of Key Changes

A number of changes have been made to natural gas consumption data presentations, definitions, and data sources. As a result of these changes the presentation of natural gas consumption by end-use sector will be consistent with end-use sector presentations and definitions in other EIA publications and the measures of natural gas used by electricity generators will be explicitly presented and identical to the quantities presented in electric power publications.

In prior EIA data publications natural gas consumption was presented for residential, commercial, industrial, transportation, and electric utility sectors. Deliveries of natural gas to independent power producers (called “other nonutility power producers” on the survey form) were included in the data reported for the industrial sector and the measures were collected through natural gas survey forms submitted by gas delivery agents (local distribution companies and pipelines).

Beginning with *Annual Energy Review (AER) 2001*, the definition of industrial sector gas consumption for 1993-2001 no longer includes independent power producers. In addition, a new electric power sector is being used which includes independent power producers, utilities, and other electricity generators as described in the previous electricity discussion. The data reported for the electric power sector are derived entirely from data submitted on electricity data collection forms used over the period 1993-2001. These include Forms EIA-759, “Monthly Power Plant Report” and EIA-860B, “Annual Electric Generator Report-Nonutility” through 2000 and Form EIA-906, “Power Plant Report” for 2001.

Compared with past publications, the impact of the definitional change for the industrial sector is to reduce measured natural gas consumption by the industrial sector. For example, in *AER 2000* EIA showed 9.39 trillion cubic feet delivered to industrial facilities in 2000. In *AER 2001*, the comparable figure (under the “other industrial” heading) for 2000 is 8.25 trillion cubic feet. This change is a result of the change in the operational definition of deliveries to the industrial sector.

Compared with past publications, the impact of the definitional change and the new data sources for the electric power sector is to increase measured natural gas consumption compared to the previous electric utility data series. As a result of the changes in data sources (predominantly new electric power data sources), total natural gas consumption is higher than previously published; i.e., total natural gas consumption has increased by 5, 3, and 3 percent in 1998, 1999, and 2000, respectively.

Also beginning with the publication of *AER 2001* and following with the *Natural Gas Annual*, new detail is available about gas consumption in the commercial, industrial and electric power sectors that distinguishes deliveries of natural gas to combined-heat-and-power (CHP) plants in these sectors from deliveries to other facilities within these sectors. “Deliveries to industrial consumers” includes deliveries to industrial consumers that are CHP plants, such as paper mills, as well as other industrial users. Included with the CHP plant data are a small number of industrial firms that report using natural gas only to generate electricity (most likely for their own use). “Deliveries to commercial consumers” also include deliveries to CHP plants, such as hospitals. Similarly, a small number of plants that report natural gas use for only electricity generation are included with the data on commercial CHP plants.

The sources for total commercial and industrial sector data are natural gas survey forms while the sources of the subcomponent CHP data series are electric power survey forms. The sources of all electric power data series, including the CHP subcomponent, are electric power survey forms.

### Publication Elements Affected

- Deliveries to industrial consumers
- Deliveries to industrial consumers for the account of others
- Deliveries to electric utilities (deleted)
- Total deliveries to consumers
- Total consumption
- Balancing item
- Deliveries to electric generators (new element)
- Average price for natural gas delivered to industrial consumer
- Number of industrial consumers
- Average annual consumption per industrial consumer

### Publication Tables Affected



Changes affect 64 of the 83 tables in the *Natural Gas Annual*.

- National-level tables (Tables 1, 26, B1, B2)
- State-level or State-detail tables (Tables 2, 15, 16, 18, 21, 23, 27, A2)
- Summary Statistics by State (Tables 29-79)

## VI. Coal Survey and Publications

### Summary of Key Changes

Data on coal consumed by the commercial and industrial sectors will now be separated into coal consumed by combined-heat-and-power (CHP) plants and coal consumed by the other plants in the commercial and industrial sector (referred to as other or “non-CHP”).<sup>11</sup> Consumption by electric utilities and independent power producers, shown separately in the past, will be combined and called “electric power sector.” Coal consumed by the electric power sector will be subdivided into coal consumed solely for power generation (“electricity-only plants”) and coal used at CHP plants. Note that “independent power producers” were previously called “other power producers” in the coal publications and tabulations. Both terms refer to the same entities, i.e., generating facilities with a North American Industrial Classification System (NAICS) code of 22.

### Coal Consumption Data Sources

The sources for total coal consumption remain unchanged for the residential and commercial sectors and for coke plants. They are:

- Residential and Commercial—Form EIA-6A, “Coal Distribution Report.”
- Coke—Form EIA-5, “Coke Plant Report.”

For the industrial sector excluding coke plants (referred to as “other industrial,”) the data sources remain the same for the following categories:

- Manufacturing—Form EIA-3, “Quarterly Coal Consumption—Manufacturing Plants.”
- Mines—Form EIA-7A, “Coal Production Report.”

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<sup>11</sup> A small number of commercial and industrial plants that use coal only to generate electricity are included with the data on commercial and industrial CHP plants.

- Agriculture, Mining, Construction, and Transportation—Form EIA-6A, “Coal Distribution Report.”

For the portion of coal consumed by CHP plants in the commercial and industrial sectors through 2000, data were obtained from Form EIA-860B, “Annual Electric Generator Report-Nonutility” and beginning in 2001, Form EIA-906, “Power Plant Report.”

Data for the electric power sector for the years 1989 through 2000 were from Form EIA-759 and Form EIA-860B. Beginning in 2001, data from Form EIA-906 will be used.

## VII. Petroleum Surveys and Publications

### Summary of Key Changes

Data on sales to independent power producers (that may have been previously reported in the industrial sector) are now included in the sales for electric power generation category in the “adjusted sales” tables of the *Fuel Oil and Kerosene Sales Report*, Tables 13-24. This category includes data on electric utilities and data on independent power producers. The data on electric utilities are obtained from Form EIA-759, “Monthly Power Plant Report,” and FERC Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.” The data on independent power producers are from Form EIA-860B, “Annual Electric Generator Report-Nonutility” through 2000, and Form EIA-906, “Power Plant Report” for 2001. Previously, some data on sales of kerosene, distillate, and residual fuel oils to independent power producers were obtained from Form EIA-821 survey, “Fuel Oil and Kerosene Sales Report” but coverage may not have been complete or data for independent power producers may have been included in the end-use sectors.

### Publication Tables Affected

Data on sales by end-use sector are published in the *Fuel Oil and Kerosene Sales Report*. Data appear in two sets of tables. Tables 1-12 publish the results of the EIA-821 survey, except for on-highway diesel and kerosene. For on-highway diesel, State-level estimates are obtained from the Federal Highway Administration.

In Tables 13-24 (Adjusted Sales), estimates of distillate fuel oil are adjusted at the Petroleum Administration for Defense (PAD) district level to equal published *Petroleum Supply Annual (PSA)* volume estimates of products supplied. On-highway diesel State-level sales are calculated from Federal Highway Administration data.

Residual fuel oil volumes in Tables 13-24 are adjusted at the national level to equal published *PSA* products supplied estimates.

## VIII. Renewable Energy Publications

### Summary of Key Changes

For the first time EIA is presenting data on biomass energy consumption that were obtained by aggregating individual power plant data for nonutilities rather than by applying a generalized heat rate to the aggregate net generation figure. All new renewable energy publications also reflect changes in EIA definitions of the energy use sectors described earlier.

### Publication Tables Affected

The main changes occur in estimates of renewable energy consumption and outputs found in the *Renewable Energy Annual's* Executive Summary, Chapter 1, and Appendix C.

### Detailed Table Changes for the *Renewable Energy Annual*

Throughout the tables, estimates of biomass consumption are based on the new methodology described earlier and result in significant revisions. Where energy use sectors are presented, information reflects the new definitions.

Table presentations remain the same for Table H1 in the Executive Summary and Tables 1 and 5 in Chapter 1. Changes to the other tables are as follows:

Table 2. Renewable Energy Consumption by Energy Use Sector and Energy Source, 1997-2001

- Commercial sector now includes energy consumption for electric-only power plants and combined-heat-and-power (CHP) plants.

Previously, this was included as a small fraction of the industrial sector's consumption.

- Industrial sector energy consumption no longer includes commercial sector or independent power producers' consumption.
- Electric utility sector is changed to electric power sector and now includes consumption for electric utilities and independent power producers combined.

Table 3. Renewable Energy Consumption for Electricity Generation by Energy Use Sector and Energy Source, 1997-2001

- Commercial sector is added for the first time. Previously, commercial sector energy consumption was included as a small fraction of industrial.
- Industrial sector energy consumption no longer includes consumption by the commercial sector or independent power producers..
- Electric utility sector is changed to electric power sector and now includes information for electric utility and independent power producers combined. Previously, independent power producers' consumption was included in industrial.
- Electric power industry is changed to total, which is the sum of the commercial, industrial, and electric power sectors.

Table 4. Electricity Net Generation from Renewable Energy by Energy Use Sector and Energy Source, 1997-2001

- Generation is reorganized into three new sectors: commercial, industrial, and electric power.
- Commercial sector includes generation by nonutilities whose primary purpose of business is commercial.
- Industrial sector includes generation by nonutilities whose primary purpose of business is industrial.
- Electric power sector includes generation by electric utilities and nonutilities that are independent power producers.
- Total by energy source is the sum of the commercial, industrial and electric power sectors.

Table 6. Renewable Energy Consumption of Nonelectric use by Energy Use Sector and Energy Source, 1997-2001

- Commercial sector now includes energy consumption for useful thermal output at combined-heat-and-power plants. Previously this was included as a small fraction of the industrial sector's consumption.
- Industrial sector energy consumption no longer includes commercial sector or independent power producers' consumption.

- Electric power sector now includes consumption for electric utilities and independent power producer combined.

Table 7. Biomass Energy Consumption by Energy Source and Energy Use Sector, 1997-2001

- Electric power sector includes wood energy consumption by electric utilities and independent power producers that were previously included in the industrial sector.
- Distributions of biomass energy consumption by Census Region are no longer included.

Table 8. Industrial Biomass Energy Consumption and Electricity Net Generation by Primary Purpose of Business, 2000

- New table that presents detailed characteristics of industrial biomass consumption.

Table 9. Waste Energy Consumption by Type and Energy Use Sector, 2000

- New table that presents detailed information on waste consumption excluding wood waste.

## Appendix B

Table B1 is a new table presenting historical renewable energy consumption for 1989 to 2001. It reflects the changes described for Table 2 above.

## Appendix C

Throughout Appendix C, information on electricity generation and net summer capacity by State, which was previously provided in separate tables for electric utilities and nonutilities, is now provided in separate tables for the electric power sector, which includes electric utilities and independent power producers, and for the commercial and industrial sectors combined.

# IX. Greenhouse Gas Emissions Publication

## Summary of Key Changes

The EIA report *Emissions of Greenhouse Gases in the United States* assigns all energy-consumption-related carbon dioxide emissions to one of four end-use sectors: residential, commercial, industrial and

transportation. A sector's emissions consist of the fuels directly burned in that sector (e.g., natural gas consumed to heat homes) as well as a share of the emissions resulting from electricity generation. Previously, emissions from nonutility generators were all assigned to the industrial sector, even though some of those emissions were based on electricity that was sold into the electricity grid and consumed in the residential and commercial sectors. Only emissions attributable to conventional electric utilities were shared out to the end-use sectors. Beginning with the 2002 publication on greenhouse gas emissions, emissions attributable to the electric power sector (which includes entities other than utilities) will be shared out to the end-use sectors. The electric power sector includes electricity-only plants (utilities and independent power producers) and combined-heat-and-power plants who are primarily in the business of selling electricity.

## Evolution of Presentation of Emissions Data

In the 2000 report a table was created that measured emissions based on electricity generation in the industrial sector and traditional electric utility emissions. Emissions from the two sources were summed to provide EIA's customers with a more complete total. However, in the end-use sector tables only the electric utility emissions were shared out. This created some confusion for EIA customers who could not add the electricity totals across sectors and arrive at the value in the stand-alone table.

In the 2001 report a table was created that presented an emissions total for both utility and nonutility generators. Unlike the previous year, this was not a stand-alone table, and the value from this table was shared out to the four end-use sectors. Because none of EIA's other multi-fuel publications allocated energy consumption in quite this same way there was somewhat of a disconnect created by this method as EIA customers could not re-create these emission values based on energy consumption in the multi-fuel, integrated publications.

For the 2002 report and beyond, the electric power sector will consist of emissions based on the multi-fuel, integrated publications that, beginning with the *Annual Energy Review* (AER), include plants whose primary business is to sell electricity (North American Industrial Classification System, NAICS, code 22). The consumption tables (e.g., *AER* Table 6.5 for natural gas) include a small amount of thermal energy produced by NAICS 22 CHP plants. In assigning emissions to end-use sectors, all of the emissions related to fuel consumed for electricity only or CHP plants remain in the



commercial and industrial sector unless they are categorized as being primarily in the business of selling electricity (NAICS 22) in which case they are included in the electric power sector as indicated above.

The electric power sector's emissions are shared out to the end-use sectors as determined by *AER* Table 8.5. Because the end-use categories in Table 8.5 differ slightly from the four detailed above in that there is an "Other"

category rather than "Transportation," an alteration is made to the data. A small amount of the "Other" category is estimated to be Transportation (4 to 6 billion kilowatthours). The rest of the "Other" category's electricity sales are allocated to the "Commercial Sector." Likewise, because there are no data to separate the "Direct Use" category, it is all allocated to the "Industrial Sector."